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This is the most recent incarnation of handbooks that have been used each year of the range-wide monitoring program. The University of Nevada, Reno and their collaborators at the U.S. Geological Survey were involved in earlier versions of the Handbook. Dr. Jay Johnson has worked in recent years to update the training program for handling tortoises and has made extensive contributions to the associated chapter in this handbook. Rohit Patil (UNR) updated data collection verification procedures for the 2012 field season and helped prepare related updates in this handbook.
# 2015 Desert Tortoise Monitoring Handbook

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INTRODUCTION

The overall goal of the U.S. Fish and Wildlife Service (USFWS) recovery plan for the desert tortoise is the recovery and delisting of the tortoise. This monitoring project contributes annual population density estimates of the Mojave desert tortoise - information that the USFWS will use to assess the status of the tortoise at various stages during recovery.

The revised recovery plan (USFWS. 2011. Revised recovery plan for the Mojave population of the desert tortoise (Gopherus agassizii). USFWS, Pacific Southwest Region, Sacramento, California. 222 pp.) requires for delisting that “Rates of population change (λ) for desert tortoises are increasing (i.e., λ > 1) over at least 25 years (a single tortoise generation), as measured…by extensive, range-wide monitoring across tortoise conservation areas within each recovery unit.…”.

The USFWS coordinates this monitoring program to

1) Collect data range-wide that are scientifically credible,
2) Use these data to develop accurate and precise estimates of population densities in each recovery unit, and then
3) Update the design and annual implementation of this project to allow detection of meaningful population recovery after 25 years.

Training outlined in this manual addresses the specialized skills required to collect these data. Desert tortoise population monitoring relies on distance sampling to annually estimate the number of tortoises in managed areas of the Mojave Desert. Distance sampling has been implemented in a variety of settings; this project trains crews in the general approach to distance sampling as well as the specifics of how this is implemented for desert tortoises. Each chapter in this Handbook addresses a focal issue, stating the training objectives and standards, and providing written reference material. The following definitions apply:

Objective: statement of aim or purpose to be pursued; a priority, or an end, towards which significant effort is directed.

Standard: Statement of the necessary activities required to meet specific training objectives. By the end of training, each crew member should feel confident in their performance of these standards.

Metric: Quantitative or qualitative means used to gauge success or failure in performance. By the end of training, instructors will have evaluated all trainees using these metrics.
2015 MONITORING HANDBOOK
1. DISTANCE SAMPLING AND DESERT TORTOISES

Although it is easy to assume that enumerating a sedentary animal (desert tortoises) in the relatively open habitat of the Mojave Desert would present few problems, this assumption is not supported by experience. A certain number of desert tortoises are underground and not visible at any given time. When they are out of their shelters, they are cryptically colored and shaped. Their behavior also does not draw attention to them. Distance sampling methods are therefore employed to correct our population estimates for the proportion that were hidden and not visible, and for the proportion that were not detected although they were on the surface.

Logistic considerations also affect our ability to estimate population size in desert tortoises. Desert tortoises are sparsely distributed and the area to be sampled is vast, resulting in the need for a large number of transects to provide an adequate sample size. The optimum period for sampling is brief (about 8 weeks in the spring), so this project is a large scale effort that must be mobilized and completed in a very short time frame. Many transects will be in terrain that is physically demanding, and tortoises are not found on all transects. This challenges observers to remain alert and attentive to the details of the methods. Departures from the methods can result in poor-quality data that lead to biased estimates. The ability to conclude anything about the status of the desert tortoise with any confidence depends on trainees performing to the best of their abilities in both the training and data collection phases.

Objective 1: Understanding how data collection affects precision and bias of the density estimate.

Objective 2: Understanding how different types of field data contribute to calculation of the density estimate.

Objective 1: Understanding How Data Collection Affects Precision and Bias of the Density Estimate

Precision and Bias
The methods involved in monitoring desert tortoise populations have two immediate objectives: to maximize precision and to minimize bias. Precision represents the amount of uncertainty (variance) in the estimate of abundance. If there is too much variance in annual estimates, the ability to draw conclusions about the magnitude or direction of change from year to year is diminished. Adequate precision in studies of wildlife abundance usually cannot be achieved with small samples. Therefore, a large number of biologists walk thousands of kilometers in the Mojave Desert each year to sample tortoise populations. Because precision is largely a function of effort, it is relatively immune to the influence of training. Training is more important for minimizing the bias in the estimates of tortoise abundance.

Bias is the discrepancy between the estimated abundance and the true abundance and can be either negative (the estimate is lower than the true abundance) or positive (the estimate is too high). It can result from both the methods employed and the set of samples used to collect the data. The first step in combating bias is a good study design. All unbiased monitoring of animal populations requires some form of randomization so that the samples are independent of the distribution of the animals. For example, the estimates of tortoise abundance would have positive bias if transects were conducted only in areas known to have large populations of tortoises. The locations selected each year for transects are designed to be as free as possible from sampling bias, so every effort should be made to conduct each transect at the selected location, and any rejected locations must be well justified. Bias can also result from improper methods or correct methods improperly applied. Training teaches the methods used to sample desert tortoises, but it should also make crews aware of the importance of following correct procedures and the larger consequences of poor quality data collection.

Desert tortoise monitoring uses line distance sampling, a modification of the strip transect method. In strip transect surveys, an observer travels down the centerline of a strip of defined length ($L$) and width ($2w$, where $w$ equals the distance from the center to the edge of the strip) and records every object observed ($n$). Density ($D$) is then simply $n$ divided by the area searched ($2wL$). This method assumes that all objects within the strip are located. If objects within the strip are not counted (Fig. 2), the density estimate will be too low (negative bias). In practice, some objects will be missed, and with a simple one-time count of the strip, there is no way to estimate the magnitude of the bias. Additional

Figure 1. Hypothetical strip transect of length $L$ and width $2w$. Eleven objects are counted in the transect, giving density $D = 11/2wL$. 
logistical problems, such as accurately defining the width of the strip, make this method impractical in most cases, especially for animals like desert tortoises that are sparsely distributed in large landscapes.

**Objective 2: Understanding How Different Types of Field Data Contribute to Calculation of the Density Estimate**

Correcting Population Estimates to Reflect Imperfect Detection

The line distance sampling method essentially adds one piece of data to the observations in a strip transect, the perpendicular distance \( d \) from the center of the transect to the object detected (Fig. 3). **Because objects close to the line are more likely to be detected than are objects farther from the line**, the distribution of detection distances can be used to estimate a probability of detection \( P_a \) within a given distance \( x \) from the transect centerline. One critical assumption in this method is that all objects on the transect centerline are detected, or the probability of detecting an object at distance 0, \( g(0) = 1 \). If this assumption is met, then density can be estimated using the general formula:

\[
\hat{D} = \frac{n}{2wL \cdot \hat{P}_a},
\]

where \( \hat{P}_a \) is the probability of detecting a tortoise within \( w \) meters of the transect line. To estimate \( \hat{P}_a \), a curve is built describing the function \( g(x) \), the probability of detection at distance \( x \) (Fig. 4). This curve is derived from the distribution of observed perpendicular distances out to a maximum distance \( w \), which defines the strip width of interest. Figure 5 illustrates our expectation.

![Figure 2](image2.png)

Figure 2. Same example as in Fig. 1, except that 3 objects have been missed (unfilled circles). The density estimate is now \( D = 8/2wL \) and has 27\% negative bias. Note that objects farther from the centerline have a greater chance of being missed.

![Figure 3](image3.png)

Figure 3. Line transect of length L. Nine objects at distances \( x_1, x_2, \ldots, x_9 \) from the line were detected. Six objects (unfilled circles) within the farthest observed distance (\( x_9 \)) were missed. After Buckland et al. (2001), Fig. 1.2.
that all tortoises on the transect line \( (g(0)) \) are detected, but tortoises farther from the line are less visible. There is no reason to expect fewer tortoises to occur farther from the line, so we interpret the graph to mean that if we had perfect vision, we could see all the tortoises represented by the rectangle \( (1.0 \cdot w) \) in Figure 5. Instead, we only see a certain proportion, \( \hat{P}_a \), which is the proportion of that rectangle that is represented by the shaded area under the curve. In essence, the density of the detected objects is used to estimate the density of the undetected (missed) objects, and these two quantities together estimate the true density.

As an example, in a given year, we might walk 8000 km \( (L \text{ in the density equation above}) \) and report seeing 100 tortoises \( (n) \) within 20 m of the transect line \( (w) \), but estimate that we only detected 50% of the tortoises that were present \( (\hat{P}_a) \). Without correcting for detection, we would estimate there are \( 100/(2*0.02*8000) = 0.312 \) tortoises per km\(^2\). However, adjusting for detection in the equation above, we refine our estimate to 0.625 tortoises per km\(^2\).

**Assumptions of Distance Sampling**

In addition to the assumption that all objects on the line are detected, two additional conditions need to be met for unbiased density estimation using distance sampling: objects are detected at their initial location, prior to movement in response to the observer, and perpendicular distances are measured accurately. Fortunately, in using line transect methods for desert tortoises, these conditions are relatively easy to meet. Desert tortoises generally do not move rapidly in response to approaching observers, except sometimes when retreating into a burrow. In this case, the distance should be measured to the point where the tortoise was first seen. Perpendicular distances can be accurately measured, particularly if the transect centerline is clearly marked.
(Anderson et al. 2001), but the method used for desert tortoises does not use a marked centerline and satisfying the second condition requires careful application of the field protocol.

Line transects for desert tortoises typically produce data suitable for generating detection functions (Fig. 5). However, these data alone do not result in unbiased estimates of abundance. Both training and field data show regular violation of the assumption that \( g(0) = 1.0 \), that all tortoises on the transect centerline are detected. Some tortoises on or very near the line will be missed, despite being available for sampling (see below). This can happen for a number of reasons, perhaps because a tortoise was hidden from view on the far side of a shrub or because the observer was momentarily inattentive. If the number of tortoises missed cannot be estimated, then the estimate of abundance will underestimate true abundance and the magnitude of this negative bias will be unknown and unknowable. To address this problem, a dual-observer technique can be used. Transects are conducted by two observers who search for tortoises independently, which allows a detection probability to be computed for tortoises on (or very near) the transect centerline. If needed, a correction factor can be applied to the estimates of abundance.

**Proportion of Tortoises That Are Not Available for Sampling**

Thus far, we have discussed the role distance plays in accounting for cryptic tortoises. A larger source of negative bias results from the basic natural history of desert tortoises. Tortoises spend a considerable proportion of time underground in burrows or in vegetation, sometimes deep enough that they are not visible to personnel conducting transects. This proportion of the population not available for sampling varies from year to year. If this proportion is not accounted for, then estimates of abundance will underestimate true abundance. Worse, estimated abundance will vary among years, probably in ways that bear no relationship to variation in true abundance, and there would be no ability to know the magnitude of the negative bias. Fortunately, if the proportion of the population available for sampling can be known or estimated, the estimate of abundance can be adjusted.

Focal tortoises equipped with radio transmitters are used to estimate the proportion of tortoises visible to sampling each year (see Chapter 6). This parameter, \( G_0 \) (pronounced “Gee sub-zero”), should not be confused with \( g(0) \) (“g at zero”) the probability of detection at distance = 0. Estimation of \( G_0 \) consists of the observation of a cohort of focal tortoises in each monitoring stratum. The focal animals are equipped with radio transmitters and observed daily while transects are being sampled in that area. Information is recorded on tortoise location and visibility. Typically, at any time during the optimal time of day, 80% of tortoises are above-ground or visible in burrows. This means that even if we adjust our density estimate to correct for lower probability of detection farther from the transect centerline, we are still underestimating the density of tortoises by 20%. To account for this “invisible” portion of the population, we use the following equation:

\[
\hat{D} = \frac{n}{2wL \cdot \hat{P} \cdot \hat{G}_0}.
\]
Starting from our example above, with 0.625 tortoises/ km$^2$, we can now consider the significance if only 80% of the tortoises were available to count. Using the equation above, we estimate there were 0.625/0.80 = 0.781 tortoises/km$^2$.

Figure 6 depicts this new information. The larger square of the graph represents the actual size of the population. The proportion described in Fig. 5 and encompassing the rectangle with an area of $1.0 \cdot w$ is only the visible portion of the total population. This visible portion comprises two parts: The proportion we see is the area under the curve in blue. The proportion that is visible but undetected (due to distance from the transect line) is in white. Finally, the portion of the total population that we discuss in this section and that is invisible in burrows is the additional area in orange.

![Diagram](image_url)

**Figure 6.** Probability of detecting a visible animal within distance $w$ of the transect centerline is the green area under the curve divided by the total area of the rectangle $1.0 \cdot w$. The rest of that rectangle (in white) is visible but undetected because as cryptic animals like tortoises are farther from the observer, they are harder to detect. This rectangle is the visible portion of the total population (the larger rectangle), which includes tortoises invisible in burrows (the orange rectangle).
2. DESERT TORTOISE HANDLING

Mojave desert tortoises have been federally designated a threatened species and are protected by state and federal laws. Proper handling is required to comply with these laws and to insure safe and humane treatment of the tortoises. Proper handling includes attention to protocols to reduce the likelihood of infection or disease transmission. Tortoises are also vulnerable to overheating and death if improperly exposed to direct sunlight and high ambient temperatures. Desert tortoise surveys include collection of data on size, sex, and health status of encountered tortoises. This handling can cause fluid loss if tortoises void their bladders. To minimize impacts to tortoise health, the U.S. Fish and Wildlife Service (USFWS) as well as state wildlife agencies stipulate permit “Terms and conditions” that are the basis for the desert tortoise handling protocols for this project.

Objective 1: Compliance with state and federal desert tortoise handling protocols.

1. Each trainee will have a thorough understanding of the important elements of the USFWS desert tortoise recovery permit terms and conditions.

2. Each trainee will have a thorough understanding of the important elements of relevant state wildlife agency desert tortoise permit terms and conditions.

3. Each trainee will fully comply in letter and spirit with every element of the USFWS and the relevant state wildlife agency desert tortoise handling protocols (or permit terms and conditions). For example, strict adherence to temperature limitations is not enough; quick, efficient, shaded, 2-handed processing of desert tortoises during handling and data collection is imperative.

Objective 2: Accurately measure, mark, examine for general health, and identify the sex of tortoises

Metrics: Trainees will demonstrate understanding of USFWS and relevant state wildlife agency desert tortoise handling protocols (or permit terms and conditions), and will demonstrate ability to handle a tortoise without violating any of these protocols. Each trainee must implement correct approaches to avoid tortoise hyperthermia, avoid loss of fluids by the tortoise, and to avoid human transmission of disease or parasites between tortoises. Each trainee must properly handle, accurately measure length, accurately determine sex of live tortoises, and accurately report body condition score plus nasal appearance and discharge.

Key Facts
The Mojave population of the desert tortoise was listed as threatened under the Endangered Species Act in 1990; recent genetic work has resulted in this “population” being designated as a full species. Potential threats to the desert tortoise include habitat loss, degradation, and fragmentation, illegal collecting, vehicle impacts, and excessive predation of hatchlings and juveniles by ravens and other species. Mycoplasmosis and other identified and unidentified infections may play a role in population declines. Non-native annual plants and their effects on fire regimes have also been implicated.
The desert tortoise is found only in the deserts of Arizona, California, Nevada, and Utah. It is the largest reptile in the Mojave Desert, and is the state reptile for both California and Nevada. The desert tortoise is without question a flagship species, and possibly a keystone and indicator species, so its persistence and recovery is culturally and ecologically important.

Desert tortoises have a lifespan of 50 to 100 years. Adults can be as large as 380 mm long, and male tortoises tend to be larger than females. Males typically have a longer tail and longer upward curving gular horns than females, as well as larger chin glands and a concave plastron; females tend to have longer rear toe nails. Despite their long life spans and hardened exteriors, tortoises can be injured or die from improper handling. Anyone handling Mojave desert tortoises or conducting scientific research on them or their habitat must have appropriate state and federal permits.

Desert tortoises are herbivores that primarily feed upon annual grasses and flowering plants. They start to reproduce at 15 to 20 years of age, and females lay 1 to 6 eggs once or twice a year. Desert tortoises spend much of their time in underground burrows, buffered from extremes of the desert climate. They are found in habitats characterized by creosote bush, salt bush, cactus scrub, shadscale scrub, and Joshua tree woodlands, usually below 1280 m (4200 ft) elevation. Historically, reported local densities exceeded dozens of tortoises per square kilometer; however no known areas support this many tortoises today. Tortoises display seasonal activity patterns with most above-ground activity between March and May and then again in September and October; they are usually underground and inactive during the rest of the year, with occasional above-ground activity probably driven by temperature and precipitation.

A distinctive feature of tortoises is their shell. The dorsal (top) shell is the carapace and the ventral (bottom) shell is the plastron. Each section of the shell is called a scute (pronounced scoot). Individual scutes, or scute series, are identified by position and/or name. Notching is used on some projects to mark tortoises, so it is one form of marking you may use or encounter.

**Objective 1: Compliance with State and Federal Desert Tortoise Handling Protocols**

Desert tortoise handling training is provided to ensure the safety and well-being of desert tortoises encountered during monitoring activities. Safe practices include basic techniques that reduce stress and likelihood of disease transmission to tortoises. These techniques also reflect terms and conditions of USFWS and state wildlife agency tortoise permits.

Once trained and approved in tortoise handling, you will be covered under a USFWS permit, and other required permits, to handle tortoises during this project. Beyond following the specific terms of these permits, you are responsible for following the guidance we provide to interact with tortoises without harming them. The brief description of proper tortoise handling procedures given here is only an overview.

*Avoiding desert tortoise hyperthermia.*

Tortoises have little effective physiological capacity to dissipate heat, so it is the handler's responsibility to guard against over-heating. Desert tortoises should not be exposed to direct sunlight. Keep them in the shade of a shrub or of your body. Remember that ground temperatures are much hotter than air temperatures, so minimize tortoise/ground contact when temperatures are hot. The critical maximum body temperature of desert tortoises is between 103°F and 112°F.
**Avoiding transmission of diseases between tortoises.**

You should handle a tortoise at all times as if it has a communicable disease. Do not allow tortoises to come into contact with your clothing or skin. Before touching a tortoise, put on a clean pair of non-porous disposable gloves (e.g. latex, vinyl, or similar material), and keep them on during the entire time you handle a tortoise. If your glove is torn during handling of a tortoise, replace it. Once used, gloves and any other disposable materials must be contained so as not to come into contact with disinfected materials, fresh gloves, equipment, or any other item that might come into contact with a tortoise. A fresh pair of gloves must be used for each tortoise. All non-disposable equipment that comes into contact with any part of a tortoise, or any instrument or item that has been in contact with a tortoise, must be treated with an approved disinfectant. Currently, trifectant or chlorhexidine diacetate are approved for use, prepared according to manufacturers’ instructions. Like 30% bleach, these are broad-spectrum disinfectants, but compared to bleach they are less corrosive and their disinfecting strength is somewhat less compromised by exposure to organic material. Once mixed, solutions may be used for up to one week.

**Avoiding loss of fluids by tortoises.**

Special precautions should be taken to prevent or minimize the fluid loss that occurs if tortoises void their bladder during handling. Do not handle the tortoise more than necessary. For the basic distance sampling project, the most important information (distance from the transect centerline) does not require handling of tortoises. It is important to minimize risk to tortoises when they are handled in the course of data collection. Always use two hands when picking up a tortoise, and do not turn it on its back or move it rapidly. Sudden movements can cause the tortoise to void (urinate), which can result in dehydration and increases risk of death. Tortoises found in burrows should only be extracted if they are accessible without reaching more than a foot into the burrow (for instance, if they are basking near the mouth), and if they can be extracted without use of force. Refer to your permits for what to do should a tortoise void its bladder. When offering fluids using an oral syringe, remember to avoid touching the syringe to the tortoise. Instead, create a slow, steady flow that moves over the tortoise’s nares and mouth. Offer fluids while positioning yourself away from the tortoise’s line of sight; standing behind the tortoise and holding the syringe behind the tortoise’s face is best. This may minimize the stress response from the tortoise and should avoid pushing material back into the nares. Offer at least a full [50 ml] syringe of fluids and as many as 2 more as long as the tortoise appears to be accepting fluids. Water offered to the tortoise should be kept separate from human drinking water. Discard the syringe if it touches the tortoise; do not disinfect.

**Objective 2: Accurately Measure, Mark, Identify the Sex of Tortoises, and Report their Health Status**

During this project you will collect information about tortoises detected on transects and encountered while on the way to and from transects. Related data will be collected for carcasses. See data sheets in Appendix I.

**Measuring tortoise length**

Of the measurements illustrated in Figure 2-1, you will measure only midline carapace length (MCL) on all accessible live tortoises. Using calipers, MCL is measured in millimeters from the
most anterior scute (i.e. the nuchal; where the head emerges) in a straight line along the carapace to the most posterior scute (i.e. the supracaudal or pygal scute; where the tail emerges).

If a tortoise cannot be removed from a burrow, it is nonetheless important to record whether unhandled tortoises are at least 180 mm MCL (“adult”) or are sub-adults. These size categories are used for density analysis, so every effort should be made to determine whether the tortoise is larger than 180 mm.

Figure 2-1. Typical measures of the dimensions of desert tortoises.

![Measures of Dimensions](image)

Plastron Length (PL): Length of the plastron (bottom shell) from gular notch to anal notch.

Midline Carapace Length (MCL): Length of carapace (top shell) along vertebral scutes from the nuchal to the rear marginal (supracaudal) scute.

**Determining sex of a tortoise**

Determining the sex of a tortoise smaller than 180 mm MCL is generally difficult. Tortoises larger than this can usually be sexed using the following guidelines, with the most reliable characteristics listed first. The easiest way to identify males is to look for a concave plastron (females have minimal or no plastron concavity). Remember, never turn a tortoise onto its back. The second most obvious characteristic is that males have longer, more curved gulars than females. A third telling characteristic is their tail. Males have long, broad, conical shaped tails, while the female tail may be just a nub at the end of the cloaca. If you are still not sure of the sex, look for chin glands – males have large well-developed chin glands that sometimes leak fluid at this time of year. When in doubt, record sex as “unknown.”

**Reporting information about tortoise health**

Although there are various metrics to describe tortoise health, many of these require blood sampling or other procedures that may cause a stress response in the tortoise. Because our project does not otherwise require such procedures, we are only collecting visual information to describe general health condition.
Specifically, you will examine the tortoise (soft tissue as well as the shell) and report whether they have no ticks, 1-10 ticks, or more than this. You will also examine the condition and discharge from their nares, which provides insight into current and chronic respiratory condition. Finally, you will examine muscle development and fat storage on the head and forelimbs to describe the overall health of the tortoise. Remember that even if an individual tortoise does not exhibit signs of illness, many diseases develop over time such that clinical signs will not apparent. Other diseases express themselves periodically, or will not be apparent based on the characteristics you are reporting. Do not at any time assume that you can relax any protocols for avoiding disease and parasite transmission.


Body condition scoring

Body condition scoring (BCS) was developed for domestic animals to estimate the average body condition of animals in a herd of livestock. This system results in a relative score based on an evaluation of muscle mass and fat deposits in relation to skeletal features. The San Diego Zoo has adapted this concept to the desert tortoise. Because tortoises can vary considerably in hydration state, length-corrected weight alone is not a good indicator of body condition. The BCS evaluates characteristics that reflect the way a tortoise’s body condition will change with life stage, season of the year, drought, food availability, and disease.

BCS is a score that ranges from one to nine. Assigning a BCS is a two-step process. The numbers are divided into 3 groups (during training, a veterinarian will use pictures to illustrate the specific scores):

- **Under condition** (scores 1-3): Because the digestive tract is relatively empty, the tortoise feels light for its size. Muscle mass on the arms is not convex (may be concave), and the muscle mass on top of the head slight enough that it is flush with the skull or concave; the sagittal crest may be visible.

- **Good condition** (scores 4-6): The tortoise has been eating, although it may be slightly lighter or heavier than expected. Muscle mass on top of the head is convex to prominent. Muscle mass along the front of the forelimb is flat or convex.

- **Over-condition** (scores 7-9): The tortoise feels much heavier than expected. Muscle mass on top of head and front of forelimbs is prominent. Subcutaneous fat deposition is apparent.
Nares condition and discharge
Discharge from nares may provide evidence of disease to the respiratory system. You will consider discharge from both nares and report the most severe version that is expressed.

  None – No discharge present.
  Serous – Clear, watery discharge present. Also report the amount:
    1. Mild - Moisture present around nares.
    2. Moderate - Discharge coming out of the nares, but not running far from the nares themselves.
    3. Severe - Discharge coming from nares that is running down the beak.
  Mucous – Cloudy, thick discharge present. Also report the amount:
    1. Mild - Moisture present around nares.
    2. Moderate - Discharge coming out of the nares, but not running far from the nares themselves.
    3. Severe - Discharge coming from nares that is running down the beak.

With chronic illness, the form of the nares themselves will be affected. Considering both nares together, you will determine whether their appearance is:

  Normal – Usual shape and/or size.
  Asymmetrical - One naris is larger and/or wider than the other.
  Eroded - Loss of scales and skin around either naris opening.
  Occluded – Plugged or reduced size of either naris opening.

Ticks
Ticks will attach themselves on soft tissue, including skin of the limbs, vent, and tail. They are often associated with soft tissues associated with the beak, eyes, and nares. Also examine the shell for possible attachment in the seams between scutes of the carapace and plastron, or on the scutes themselves.

Marking a tortoise
Paper tags will be affixed to a scute of each unmarked tortoise. Minimize the abrasion the tag will be subjected to; select a scute with a natural depression, considering first any of the costals, then the vertebals (if the depression is quite deep- vertebals endure a lot of scraping). Because tortoises are often relocated head-down in burrows, using the 4th right or left costal scute will increase the likelihood the tag will be read. When affixing the tag, under no circumstances should epoxy touch the margins of the scutes, where growth must occur. Subadult tortoises with scutes that are too small to safely affix tags should not be marked.

In addition to recording information for the new tag you attach, you will be asked about markings or tags that are already present on each tortoise. Floy© tags were used by range-wide monitoring crews in 2005 and 2007, and paper tags were used since 2008. Besides the use of tags, many researchers mark tortoises by notching the marginal scutes (Figs. 2-2 and 2-3).
Figure 2-2. Tortoise Scute Identification. Individual scutes, or scute series, of the plastron (lower shell) and carapace (upper shell) of desert tortoises. As illustrated for costals, individual scutes are identified by counting from anterior to posterior; marginals are also identified as left (L) or right (R) from the tortoise’s perspective.

The notching system used for most current translocation projects is the “highly modified Honegger system,” illustrated below. When you are not notching, do not assume you know the system used on a particular project – there are many of these systems! Simply report the side and marginal number(s) with notching: e.g., L9 / R2,9,11 is the accurate report of notches in Fig. 2-3.

When notching, remember that bone seams are generally offset from scute seams, so avoid notching directly in the middle of the scute. Also avoid creating fragile, narrow, breakable scute fragments by notching close to the scute seam. Notches should be as large and defined as possible without marking the underlying bone. Once you have finished all notches, it is good practice to revisit each one with an eye on optimizing the size of the notch.
Figure 2-3. The Highly Modified Honegger notching system. The illustrated notching pattern corresponds to the number “245,” and when encountered would be reported as “L9 / R2,9,11”

Carcasses
Only report carcasses if at least half of the shell is present, or if a smaller part of the carcass is available but identifying marks are present. Record MCL and sex of carcasses only if you are able to determine these measures accurately. If the carcass/carapace is not sufficiently intact to measure MCL, it is “disarticulated.” Other projects may have a different operational definition for this term. Some projects also request information on “Carcass class”:

Carcass Classes
1. fresh or putrid
2. normal color, scutes attached
3. scutes peeling off bone
4. shell bone falling apart and scute rings peeling
5. disarticulated, scattered
Approaching and collecting data on desert tortoises

The order of the following steps is meaningful and is designed to 1) start at a distance and move closer, 2) move from least to most disruptive of the tortoise, and 3) minimize actual handling time. If you are working in a two-person team, establish which person will handle the tortoise and contaminated materials and which will handle uncontaminated materials and record data.

- Always use your “field voice” when out in the field
- When a tortoise is located
  - Observe the tortoise and its surroundings
  - Put away non-handling equipment
    - Place pack several meters away from tortoise (out of tortoise sight)
  - Identify an area for processing the tortoise
    - Shade of vegetation preferable or use your own body
    - Several meters away from burrow entrance if nearby
    - Place thermometer in the shade approximately 10 cm above where the tortoise will be handled to ensure suitable temperatures
  - Observe whether the tortoise has an existing tag and/or has been notched
  - Make basic observations of body condition score
  - Finish recording any distance data prior to handling tortoise
  - Remove needed handling gear from the pack; place in the processing area
    - Place tape and calipers on the ground at the processing area
  - If an existing tag is present, use a small amount of non-drinking water to clear dust and read the tag number.
  - At the backpack, cut out the paper tag and mix the epoxy on cardstock.
  - Record all relevant fields, such as transmitter or ID tag number, prior to attaching it to the tortoise and handling.
- If temperatures are suitable for handling, move the tortoise to the processing area
  - Put on latex gloves
  - Approach and pick up the tortoise from behind using 2 hands, one on either side of the shell.
  - Keep the tortoise close to the ground and in correct orientation.
  - Keep all clean equipment on the left side of the tortoise
    - Place the measuring tape on the ground to the left of the tortoise
    - Do not place equipment under the tortoise
    - Do not place gear where the tortoise might step on it.
- Apply ID tag if necessary
- Hold calipers near the tips to move them to the correct measuring position.
- Read MCL by placing calipers on the ground next to but not touching the tape.
- If needed and with the tortoise close to the ground, lift and tilt the tortoise slightly to view plastron and tail for sex determination
- Observe tortoise for any health abnormalities (if indicated) and to better assess body condition score. Count ticks (if indicated)
- Notch and apply transmitters to shells (if indicated)
  - Handle only parts of non-disposable gear that can be disinfected
- Continue to place all contaminated items to the right of the tortoise while working.
- Do not return tortoise to its original location
• Pick up cardstock, Q-tips, and other contaminated disposable items in one hand.
  o Turn this glove inside out as it is removed in order to contain the trash
• Remove other glove, taking care to not contaminate skin, then place both gloves in the
disposal bag taking care to not contaminate the outside of the bag.
• Finish recording all data gathered if working alone.
• Open disinfecting solution and apply liberally to equipment or to the cloth/toothbrush
used for cleaning
• Apply a new pair of gloves and use the cloth or toothbrush to remove any dirt and debris
from contaminated items
  o Completely cover all contaminated areas with liberal amounts of disinfectant
    solution and allow to air dry.
  o Place items in the sun to allow for further UV disinfection
• Survey area for any trash or equipment left on the ground prior to leaving
• Remove gloves and place them in the trash bag.
• Place the cleaned equipment and trash bag back in the pack
  o Use standard separate locations in pack
3. COMPASS AND NAVIGATIONAL GPS

Two different methods of navigation will be used while you conduct monitoring. You will use a navigational GPS to locate transect start points, keep track of meters walked, check the Juno grab for validity, and return to your vehicle from the transect. A compass will be used to set and hold the correct bearing as you walk, and to report azimuth and bearing. The integrated Juno GPS is not for navigation; it is used solely to transfer location data to the collection system.

The goal of Compass and Navigational GPS training is to enable you to confidently and correctly apply your existing knowledge of GPS and compass navigation to distance sampling. It is expected that you already have a basic understanding of how to navigate with a compass and a standard recreational grade GPS unit. These skills are crucial to collecting data, as well as to your personal safety and the safety of those around you.

**Objective 1:** Basic understanding of GPS.
Navigational GPSs are provided by each monitoring team, so unit set up, operation, and maintenance are the responsibility of each team. Emphasis in USFWS training is on application to distance sampling for desert tortoises.

- **Standard:** Understand GPS basics, including what GPS is and how it works
- **Standard:** Understand coordinate systems and how they are applied to GPS
- **Standard:** Understand the importance of GPS signal strength
- **Standard:** Correctly utilize GPS in the context of distance sampling surveys

**Objective 2:** Basic understanding of compass use.
Compasses are provided by each monitoring team, so compass set up, operation, and maintenance are the responsibility of each team. Emphasis in USFWS training is on application to line distance sampling for desert tortoises.

- **Standard:** Know basic compass terminology and anatomy
- **Standard:** Understand the difference between true and magnetic north.
- **Standard:** Correctly utilize compasses in the context of distance sampling surveys

**Metrics:** Trainees will be evaluated on use of compass and navigational GPS through practical exercises, including performance on training lines and navigation on practice transects. Proficiency must be demonstrated by everyone conducting distance sampling.
Objective 1: Basic Understanding of GPS

- **GPS Basics**
  - What is GPS - The Global Position System (GPS) was originally developed for military purposes by the U.S. Department of Defense. In the 1980s, the system, which provides positioning, navigation, and timing (PNT) services, became available for civilian use. In addition, in 2000 selective availability\(^1\) was turned off. There are three basic elements to the system (www.gps.gov):
    
    i. The space element is made up of a constellation of 24 operating satellites that transmit one-way signals of the GPS satellite’s current position and time.
    
    ii. The control element consists of monitor and control base stations around the world that ensure the satellites stay in their proper orbits and stay accurately aligned.

    \(^1\) Selective Availability (SA) is the intentional degradation of GPS signals that was put in place by the U.S. Department of Defense as an attempt to prevent military adversaries from acquiring highly accurate GPS data. SA was turned off in May of 2000, vastly improving the accuracy of civilian GPS receivers.
timed. These stations also track the GPS satellites, update them with navigational data as it becomes available, and collectively maintain the health and status of the GPS constellation.

iii. The final element is the end user, consisting of the GPS receiver equipment and you, the equipment operator. The equipment uses GPS satellite signals to calculate the user’s three dimensional position and time. If applicable, it displays this information to the user in an understandable way.

- How GPS works –
  i. Each operational GPS satellite circles the earth in a very precise asynchronous orbit twice a day, transmitting signal data to active, within-view GPS receivers.
  ii. The receiver uses the signal data to calculate the user’s location through triangulation.
     • Triangulation compares the time a signal is sent by a satellite with the time it was received to determine how far away the satellite is.
     • Triangulation requires at least three satellite signals to determine a 2 dimensional location (x and y).
     • With four or more satellite signals, a receiver can calculate its 3 dimensional location (x, y, and z [i.e. altitude]).

iii. Once the location is determined, the receiver can track speed, distance, elevation gain, and other information.

- Coordinate Systems and GPS – Geographic coordinate systems allow any point on Earth to be defined and represented by a numbering scheme, the most common of which is latitude and longitude, but monitoring data will be collected in the Universal Transverse Mercator (UTM) coordinate system.
  • Most GPS receivers come out of the box set to latitude and longitude, so you may need to refer to the user manual to change the settings. Your display units must be in UTM.
  • UTM is typically a better coordinate system for navigating across and collecting data on smaller areas, like transects and monitoring strata. When navigating larger distances, the latitude longitude system is easier for pilots and sailors to use.
  • The UTM grid system originated in 1947 out of the U.S. Army’s need for a way to designate rectangular coordinates on large scale (i.e. small area) military maps, but is becoming more prevalent because the coordinates are easier for the typical civilian navigator to use than latitude and longitude.
With the UTM system, the earth is divided into 60 zones, numbered 1 (at the International Date Line) and proceeding east to 60. Each zone is 6 degrees of longitude wide.

Each numbered zone is then divided into horizontal lettered bands that span 8 degrees of latitude, starting with C in the south and proceeding to X in the north. I and O are skipped due to their similarity to 1 and 0. The map below shows the entire UTM grid system.

UTM coordinates are expressed in Easting and Northing

i. Easting – easting is measured from the vertical center line, or central meridian, of the zone. The center line is given an arbitrary value of 500,000 meters, so anything to the west of the central meridian is less than 500,000, and anything to the east is greater. Because the zones are 6 degrees wide and never more than 674,000 meters wide, an easting of zero is not possible.

ii. Northing – northing is measured relative to the equator.

- In the northern hemisphere, the equator is assigned a value of 0 meters north and increases as you travel north.
- In the southern hemisphere, the equator is assigned a value of 10,000,000 meters north and decreases as you travel south, which avoids the possibility for negative numbers.
- It is possible to have the same Northing value in the north and in the south, but confusion is avoided by including the letter of the latitude band or by including North or South.
- Because Northing is determined based on the equator instead of the latitude bands, the bands become unnecessary and are often not used.
- Many GPS receivers denote whether the northing is north or south of the equator by simply adding N or S to the number. This can create confusion.
because southern Nevada and California are in UTM Zone 11 latitude band S, but on your navigational GPS, it will likely show up as UTM Zone 11N because it is north of the equator).

- Arizona and Utah transects are in UTM Zone 12 and your navigational GPS unit should automatically switch to the new zone as appropriate. The map below shows the UTM zones of the U.S. with Longitude along the top.

![UTM zones map](image)

- Datum – A datum is the model used to match the location of a feature on the ground to the coordinates of the feature on a map. GPS uses the World Geodetic System (WGS) 1984, an Earth-centered datum that was adopted from the North American Datum of 1983. Make sure your navigational GPS is set to UTM, WGS 1984.

3. **How GPS is Applied to Monitoring** - While completing a transect, you will use both a navigational, interactive GPS unit and the non-interactive GPS that is integrated into the Juno. The navigational GPS unit is not provided by the USFWS, so training on menu navigation and GPS care is up to you and your team leaders.

- The navigational GPS unit will be used in five different ways:
  i. Navigating to a transect start point – for each transect assigned to you, it is up to you, and your group to determine how you will get to the nearest access point on the transect.
  ii. Keeping track of meters walked – most navigational GPS units display distance traveled. Instead of pacing 500 meters in your head as you walk, use the GPS interface to track distance traveled since previous waypoint.
  iii. Recording GPS coordinates on paper – At each waypoint, record navigational GPS coordinates on the paper sheets. These coordinates may not match those grabbed into the electronic form, so they provide important information.
  iv. Checking the validity of the Juno grab – Compare electronic and navigational GPS coordinates to confirm validity of the electronic version. This comparison is important when
- Your Juno has been off for more than an hour
- Your HDOP is six or more
- There are fewer than five available satellites
- The grab took an unusually long amount of time

v. Recording coordinate data if the integrated Juno GPS grab does not work – At some point during your monitoring duties, your Juno GPS unit may not take a grab for one reason or another. In this case, manually enter the easting, northing, and zone from your navigational GPS into the electronic database.

vi. Finding your way back to your vehicle – If necessary, use the navigational GPS unit for its most traditional purpose – finding your way from point A (transect end point) to point B (pick up location).

- The GPS unit integrated into the Juno is used for one purpose only – to capture coordinate data in the electronic database.
  i. You will use the Juno unit whenever you record a waypoint, tortoise, or carcass.
  ii. Automatically transferring coordinate data eliminates the opportunity for human-caused error.

4. **GPS Signal Strength** – Reliability of a GPS satellite reading or grab is almost entirely dependent on the strength and geometry of the signals coming from the satellites.
- There are occasions when a GPS signal weakens, becomes undetectable, or degrades before it reaches a GPS receiver. When and why this degradation occurs:
  i. Ionosphere and troposphere delays – As the satellite’s signal passes through the atmosphere, it slows down, disrupting the receiver’s triangulation calculation (see graphic below). This is partially compensated for through a built-in calculation based on the average delay time.
  ii. Signal multipath happens when the GPS signal bounces off of a surface, like a tall building or a large rock formation, before reaching the receiver. This increases the travel time and causes a calculation error (see graphic below).
iii. Receiver clock errors occur when the built-in clock is not as accurate as the atomic clock on a GPS satellite, causing slight timing errors.

iv. Orbital errors occur when the reported location of a satellite is inaccurate.

v. Number of satellites visible – The more satellites a GPS receiver has clear access to, the better its positional accuracy will be. Satellite signals are blocked or degraded by buildings, mountains, dense foliage, and other electronic signals, and typically do not work indoors, underground, or underwater.

vi. Satellite geometry – The spread, or geometry, of satellites available to a receiver can affect the accuracy of a reading. When satellites are closer together in the sky, the reading is likely to be less accurate than one from satellites that are spread out. The goodness of satellite geometry is expressed most commonly as HDOP or PDOP (Horizontal or Positional Dilution of Precision):

- Knowing what makes a signal go bad or get interrupted can help you get the best signal possible. Here are some other tips:
  i. The receiver needs as clear a view of the sky as possible – since your body can block a signal, hold it out in front of you with your arm extended.
  ii. Many navigational GPS units have a Skyplot option, which lets you see the position and the strength of available satellites. This can help determine if you need to compare the Juno grab coordinates to the navigational GPS coordinates.
  iii. The signal is more likely to introduce error to the grab when you are in an area with large rock formations or rocky substrate. In situations like this, the GPS reading is likely to bounce around as it refreshes. If readings vary more than 20m, the grab is more likely to be poor. Compare the grab to the most consistent navigational GPS reading.

- For more detailed information on GPS, visit [www.gps.gov](http://www.gps.gov).
Objective 2: Understanding Compass Basics

1. Basic Compass Terminology and Anatomy
   - **Bearing and Azimuth:** Bearing and azimuth refer to direction in degrees and are determined using your compass. For our purposes, bearing is the direction in degrees you walk along a transect, whereas azimuth is the angle from the line you are walking to a tortoise or carcass. Both range from 0 to 360 degrees.
   - **Compass Anatomy:** The four most important pieces of your compass, and the ones that you will use every day are the direction of travel arrow, orienting arrow, magnetic needle and compass housing. Compasses are provided by each monitoring team, not by the USFWS. Therefore, our description of compass anatomy may vary from what your actual compass looks like or comes with.
i. **Compass Housing:** the sealed center compartment of the compass that contains the magnetic needle and a liquid that allows the needle to move freely, but not rapidly or shakily

ii. **Baseplate:** the bottom part of the compass that you hold flat in your hand; includes the direction of travel arrow and any millimeter and inch scales

iii. **Direction of Travel Arrow:** points in the direction you should travel after setting your bearing

iv. **Magnetic Needle:** located within the compass housing and is typically a red and white needle; the red end is magnetized and points to magnetic north when the compass is held steady and flat

v. **Degree (Bearing) Dial:** the numbers located along the compass housing that indicate the angular difference in degrees between any point and magnetic north (can be adjusted for declination); bearings range from 0 to 360 degrees

vi. **Orienting Lines:** parallel lines in or on the compass housing and base

vii. **Orienting Arrow:** stationary arrow within the compass housing

viii. **Declination Adjuster:** typically a small notch on the back of the compass that requires a key to turn; allows you to adjust for declination (not shown on figure). You must have a compass with an adjustable declination.

2. **Basic Compass Navigation:** Correctly navigating with and reading a compass is an essential part of monitoring. The steps below explain what you need to know, and should be a review.

   ![Compass Diagram](image)

   **Follow a Bearing (i.e. use a compass to walk in a certain direction):** On transects you need to follow a bearing; a compass will help you keep on that bearing. You will mainly be heading north (0), east (90), south (180), and west (270), focusing the majority of your attention on finding tortoises, and only occasionally checking that you are following the correct bearing. Here’s how:

   i. With the compass open, the bottom held as flat and steady as possible, and the direction of travel arrow pointing away from you, rotate the compass housing until the desired degree lines up with your direction of travel arrow (i.e. 0, 90, 180, 270).

   ii. With the compass held directly in front of you at chest level, turn your body until the magnetic needle lines up with the orienting arrow. In nearly every compass Red in the Shed is the rule.
iii. Now lift the compass to eye level and fold the mirror until you can see the arrow’s reflection. Make sure they stay aligned during the next step.

iv. Look down the direction of travel arrow, beyond the compass, and find an object that stands out (i.e. a Joshua tree off in the distance, prominent mountain features) and lines up with the direction of travel arrow.

v. Walk towards the chosen object, glancing up occasionally to ensure you are still on the right path.

vi. If a distant navigational target is not available, pause every hundred meters or so to check your bearing and identify new, closer targets as necessary.

- **Read a Bearing from a Map:** Occasionally you may reflect a transect and travel in a non-cardinal direction. To read the correct bearing from the map, you will orient using the north arrow and base lines on the map.
  
i. Settle the baseplate of the compass on the map so that the compass housing straddles the path for which you will determine a bearing.
  
ii. Rotate the compass housing so that the compass orienting lines are parallel to north-south base lines on the map; the 360 position on the degree dial now indicates north as depicted by the map.
  
iii. Read the bearing of interest where the mapped path crosses the degree dial.

- **Take a Bearing (i.e. use a compass to find your direction of travel):** You will record a local bearing and a transect bearing each time you find a tortoise or carcass. The transect bearing is the bearing that you planned to walk (i.e. 0 for North, 90 for East, etc.); this is a planned, not a measured quantity. You will use your compass to take the local bearing, which is the bearing you are actually walking. *We want you to focus on looking for tortoises rather than looking at instruments to stay on an exact bearing the whole time, so we also expect that your actual bearing will vary from the transect bearing, but hopefully not too much.* The directions below assume you have a compass with a folding mirror.
  
i. With the compass open, the bottom held as flat and steady as possible, and the direction of travel arrow pointing away from you, hold the compass up to your sighting eye.
  
ii. Standing at your position (leader or follower), line up the direction of travel arrow with the 25m tape. **NOTE:** The bearing measured back from the leader position (“back-bearing”) will be 180° different from the bearing from the follower position. Either bearing will give the correct calculation.
  
iii. Fold the mirror portion so you can see the magnetic needle and orienting arrow in its reflection. Keeping the compass steady, rotate the compass housing with the bearing degrees until the orienting arrow (hollow and within housing) lines up with the north end of the magnetic compass needle, so the red end of the magnetic needle fits nicely within the hollow of the orienting arrow. Red in the Shed!
  
iv. By using the mirror, you avoid lowering the compass and shifting its orientation as you line up the orienting arrow with the magnetic needle. Look in the reflection to align the two, then lower the compass and record the bearing at the index line. That is the local bearing.

- **Take an Azimuth (i.e. use a compass to find the direction of an object):** Accurately recording the distance a carcass or live tortoise is from the transect line you are walking is an essential part of monitoring. The calculation of this distance requires the exact
azimuth and distance of the tortoise from where you spotted it on the transect line. To take an azimuth:

i. Immediately stop walking when you spot a live tortoise or carcass. It is important to record the azimuth from where you first spotted it, not two steps down the line.

ii. With the compass open, the bottom held as flat and steady as possible, and the direction of travel arrow pointing away from you, hold the compass up to your sighting eye.

iii. Without stepping from your spot, rotate your body until you can point the direction of travel arrow directly at the tortoise or carcass.

iv. Fold the mirror down until you can see the magnetic needle and orienting arrow reflecting in the mirror.

v. Rotate the bearing dial until the magnetic needle and orienting arrow align in the mirror. Meantime, keep the direction of travel arrow pointed directly at your find.

vi. Once the arrows are aligned, lower your compass and record the bearing number that aligns with the direction of travel arrow. That is the azimuth of the tortoise.

3. **True and Magnetic North:** When navigating by compass, there are two different Norths to consider: the north that can be found on a map (true), and the north that a compass points to (magnetic).

   - **True North** (also geographic north or map north): True north is the geographic North Pole where all longitude lines on a map meet. Nearly all maps have a north arrow indicating true north, but a compass’s arrow points towards magnetic north.
   
   - **Magnetic North:** The earth is a giant magnet with a magnetic field that is inclined at about 11 degrees from the planet’s axis, so magnetic north and true north do not usually line up. Because Earth’s core is molten, the magnetic field is shifts gradually. This magnetic field pulls the magnetic arrow within a compass away from true north and towards magnetic north.
   
   - **Declination:** Declination is the angular difference between true north and magnetic north. Declination depends on where you are:

![General lines of declination in the United States (1998)](image-url)
• **Declination for Tortoise Monitoring:** In Mississippi, we wouldn’t have to worry about declination; true north and magnetic north would more or less line up. Declination values are expressed as Easterly (positive) or as Westerly (negative) values. When magnetic north is east of true north (as in the southwestern US), the declination is positive. In an added twist, the lines of declination shift westward about 0.5 to 1 degrees every year. So although declination is indicated at the bottom of many local maps including all USGS topographic maps, older maps will not reflect current conditions. A declination calculator for a particular area on a particular day can be found at [http://www.ngdc.noaa.gov/geomag-web/](http://www.ngdc.noaa.gov/geomag-web/). For instance, the declination in Barstow, CA on 10 April 2015 will be 12 degrees and 8 minutes east and in Las Vegas, NV it will be 11 degrees and 55 minutes east. After you adjust your compass to compensate for declination, recheck the setting at least once a week.

• **Example to further clarify declination:** You are starting a transect near Las Vegas and want to travel along a true north bearing (0°). Because the area around Las Vegas currently has a declination value of about 12 degrees east (+12), when your compass indicates 0° from magnetic north, you are actually traveling a bearing of 12° from true north (0 + (+12) = 12°). To travel a true 0° path, subtract 12° from your planned bearing. Following a bearing of (360-12)=348° will compensate for declination and result in a true 0° path. Instead of doing this on the fly you should adjust your compass for declination. When the declined compass indicates a bearing of 0 degrees, you are following true north.

• **Adjusting for Declination:** The compass you use on transects must adjust for declination. Here’s how to adjust for declination in the Las Vegas area:
  i. As you will be walking transects that have easterly declinations, you will need to follow a bearing of twelve degrees less than magnetic north.
  ii. On the back of your compass, there should be a small screw that you can turn with the key provided on the lanyard. Turn the screw until the magnetic north arrow points at 12. After adjustment, your bearings and azimuths will report true bearings and collect true azimuths.
  iii. **If you fail to adjust for declination, your first 3km segment will be ~750m off (~250m/km), with the error compounding as the transect gets longer.**
4. ELECTRONIC EQUIPMENT CARE AND MAINTENANCE

We use an electronic data collection system for tortoise monitoring to enhance the accuracy, validity and integrity of the data you collect. Effective use of an electronic data collection system, compared to a solely paper based system, allows us to:

1) reduce data entry errors such as misspelled words (carcass and carcas are not the same), by providing such tools as look up lists and drop down menus,

2) eliminate the problems associated with hand-entered data (e.g., data entry errors due to repetitive tasks, undecipherable data from poor hand writing, lost data sheets),

3) reduce the time from field data collection to data assessment, final QA/QC and analysis,

4) enhance QA/QC by automating certain operations directly in the field and providing in-office QA/QC tools, both of which assist the contractor in providing the best data possible, and

5) automate and consequently reduce errors in spatial data collection (GPS grabs).

The goal of Electronic Equipment Care and Maintenance training is to enable you to confidently and correctly care for and operate the data collection equipment in your duties as a tortoise monitor. This portion of the training does not deal with what data to collect (e.g. MCL) or how to collect it (e.g. Tape measure, calipers, etc.). The outline below details the individual objectives and standards, as well as the final metric for which you will be held accountable after completing this training.

Objective 1: Proficiency with basic Juno operations.

You are responsible for ensuring that your Juno is operational and correctly set up each day. Each crew member will know how to

1. set up the Juno (e.g. charge, turn on/off, set date/time, components of Juno)
2. navigate menus
3. back up data
4. restore data
5. maintain the unit
6. troubleshoot common Juno problems through a soft reset or a hard reset.
Objective 2: Proficiency with built-in GPS receiver.
You are responsible for ensuring that your built-in GPS is operational each day. Each crew member will know
1. how to set up built-in GPS (with GPS controller)
2. how to adjust real-time settings

Objective 3: Proficiency with built-in Camera
1. Parts of the Camera and taking a picture
2. Adjusting camera settings

Metrics: During training you will be asked to demonstrate for an instructor how to set the Juno date and time; back up data; perform a soft reset; perform a hard reset and restore data and Pendragon Forms, and must successfully perform all tasks. Individuals will be given two opportunities to pass so they can participate in sampling.
Objective 1: Understanding Basic Juno operations

1. Setting up the Juno
   - Components
     i. the Juno itself,
     ii. USB cable used to connect to the computer,
     iii. AC adaptor cable used for charging,
     iv. Vehicle power adapter for charging, and
     v. Stylus, which is stored on the unit and used for entering data on the screen.
   - Charging the unit: Connect the AC adaptor to the bottom of the Juno at the power connector port. Plug the AC adaptor into a wall outlet. For safety reasons, make sure the Juno is completely dry before plugging it in. On a completely drained battery, charging time takes about 4 hours. Unplug the safety adapter when not in use.

You can tell how full the battery is by following these steps:
   i. Turn Juno on, the power LED beside the power key indicates battery power (LED off is good battery level, LED flashing red is less than 5% battery level)
   ii. From the home-screen (Press Today to go to home-screen), tap on top title bar to open battery information screen. This screen displays the Battery Percentage remaining .
   iii. Press the OK Button to return to the home-screen

- Turn the unit on or off: Briefly press and release the Power button to turn the unit on. When turned on, it will return to the screen you were previously working with unless the battery has been drained or it has been turned off for an extended period of time. To conserve battery power put the unit in suspend mode by briefly pressing the
power button (i.e. between waypoints); the unit does this automatically when not in use for 30 seconds. Briefly press the power button to return from suspend mode. To turn the unit off, press and hold the power key for 5 seconds till completely off. It is recommended that the device be turned off only if it will not be used for three months or more.

- **Setting Date and Time**: Turn unit on and press the Today button if necessary. Tap on icon to open Date & Time settings. Tap the date to set it (make sure you’re in the right year), Tap on the time to set it, select the correct time zone.

- **Screen Contrast**: Tap , then Settings, then select System tab, then tap on Backlight. Check the box to turn off the backlight when the device is not in use, and select the time for 30 sec. You can also access the screen brightness control using the “configure” tab at the bottom, and then use the battery power slider to adjust darkness and brightness. Adjust the brightness to your liking in the field but remember that battery power is conserved when the screen is darker. Press OK when finished, and then Press .

2. **Navigate Menus**: Menus on the Juno are navigated largely by using the stylus; however, shortcuts with the buttons have been created to navigate to the desired programs quickly. Below are the buttons and the programs they are linked to.

<table>
<thead>
<tr>
<th>Button</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Today Button</strong>: Pressing the Today button will take you to the home-screen, whether a program is running or not. The button only needs to be Pressed once. If lost within the Juno, Press Today and start again.</td>
<td></td>
</tr>
<tr>
<td><strong>Start Button</strong>: Pressing the Start button will display the Windows Mobile Start Menu. From the Menu, programs and device settings can be accessed.</td>
<td></td>
</tr>
<tr>
<td><strong>Left Soft-Button</strong>: Press this button and it will open up Pendragon Forms. Once in the forms program, use the stylus to navigate through the data collection process.</td>
<td></td>
</tr>
<tr>
<td><strong>Right Soft-Button</strong>: Press this button and it will open the Sprite Backup program, which is used to perform backups after every waypoint. If the device becomes unresponsive or requires a hard reset, the device and any collected data can be restored using these backups.</td>
<td></td>
</tr>
<tr>
<td><strong>Mail Button</strong>: This button has not been configured.</td>
<td></td>
</tr>
<tr>
<td><strong>OK Button</strong>: Pressing the OK button will select the OK option or close the current application.</td>
<td></td>
</tr>
</tbody>
</table>
3. **Back up data:** The equipment you will be using is good, but not perfect; and at some point during your monitoring duties, chances are that the batteries will run down or the Juno will freeze up and require a hard reset (described in Standard 6 of this objective), losing all data and non-default applications. Because of this, **it is crucial that you know how to create backups of and restore the data you collect while walking transects.** You are expected to backup your data at every corner while walking on the transect and to know how to restore it on your own. It is simple to do, it takes only a couple of minutes, and will save you from having to re-enter or re-collect data if your Juno crashes or runs out of juice. Here’s how:

- While in the home-screen area (press Today if needed), press the right soft key button to start the Sprite Backup program.
- Use the stylus and select Backup to start the process. If the backup file (Backup.exe) already exists on your SD card then you will see a confirmation message to replace the old file. Select "Yes" to replace the existing backup file and start the backup process. Do not operate the device while backup is in progress and until you see a notification "Backup Complete". The device will reset multiple times during this process.

- On the notification message click "View Report" and check the status to confirm the Backup was completed successfully. Tap on OK and continue where you left off.
4. **Restore data and Pendragon Forms**: Your Juno has crashed and you had to run a Hard Reset (explained in Standard 6 of this objective), after which Pendragon Forms is no longer available and your data is gone. Do not panic, this happens from time to time. As long as you have been implementing regular backups, you will be back in operation in no time, just follow these steps:

- Before you restore the Juno ensure that Date and Time settings are correct. If necessary, change the settings as described earlier under "Setting up Juno". A hard reset erases all data, installed applications, and settings in the handheld, with the exception of data or applications that were pre-installed on the handheld or are stored on a memory card. The device must be restored to make available Pendragon forms, other supporting applications, and any of your collected data that you have backed up. To restore the device, press then choose Programs, and select File Explorer.

- In the File Explorer Program, click on "My Documents" (on top left as shown below) and select the SD-MMC card location. You will see the contents of the memory card and the Backup file that you previously created (Backup). Click on the Backup file to initiate restoration of your data and settings.
• This will take you to the Restore Data Selection Page. Make sure all folders are checked, and Press next.

• The Juno must go through a reset for the restore process to be complete. Press Next to Reset the Device. You will be given a restoration report at the end of the process. Just Press OK and the Restore is finished.

• Everything should be back to normal, but you’ll probably have to re-collect whatever data you were working on when the Juno froze and re-enter anything that was not backed up.

**NOTE:** Perform a restore only after data loss (i.e. dead battery, hard reset); do not use the restore function as a means to undo mistakes.
5. **Maintaining Your Juno:** The Juno is basically a field computer running Windows Mobile operating system. It has an integrated high sensitivity GPS receiver with 5 m accuracy when using real-time differential correction. They are durable devices, but are not fully rugged. We have added a case onto it but that does not make them rugged, waterproof or immune to dirt. Do not remove the Juno from its case under any circumstances. If there are technical issues, hand over the unit to the data specialist for your team.

- **Keep the screen clean.** Touch-screens are great, but present a host of problems when used in the field. The Junos are enclosed in protective cases but their screens are only covered with a thin plastic cover. If care is not taken the screen can easily be scratched or damaged. Here are some tips for screen care:
  
i. The provided **stylus** is the only object that you should ever use to Press or write on the screen. Do not use your fingernail, a pen cap, a twig, a pencil, or any other object you might think is suitable. Carry extra styli with you, they come cheap from any computer store.
  
ii. If the case, protective plastic screen cover or the stylus is dusty or dirty, gently wipe them down with a clean cloth, damp if possible.
  
iii. When stowing the Juno in your backpack, be aware of its placement. In the past, many screens have been ruined simply by the way they’re carried around or stored. Do not store the Juno in your backpack and then use your backpack as a chair.

- **Cleaning and storing the Juno:** You and your Juno are likely to encounter dirt and mud, if you are lucky enough to be rained on while walking transects. To clean the Juno, use a clean, damp cloth or, if really dirty, a soft bristle brush (do not use on screen). Make sure the Juno and all its protective covers are clean and completely dry before charging or operating. Store in a cool, dry place.

- **Battery Care:**
  
i. The Juno comes with a custom rechargeable Lithium Ion battery pack. You should never remove or handle the Juno’s battery pack. For that matter, you should never attempt to remove the protective case on Juno.
  
ii. Use only the vehicle power adaptor or AC adaptor to charge the unit. The included USB data cable is not used for recharging the Juno.
  
iii. If possible, charge every night and avoid fully discharging the battery. Unlike most rechargeable batteries, Lithium Ion batteries will have a longer life span when consistently only partially drained.
  
iv. Again, make sure the unit and cables are **completely dry** before plugging into an electrical source. Clean connections with a clean, dry cloth or compressed air, taking care not to freeze anything.
  
v. Do not immerse battery in water, store in a hot vehicle, drop or puncture it, and do not open it.
6. **Troubleshoot Common Juno Problems:** There are two typical ways to troubleshoot a non-responsive Juno: a soft reset and a hard reset. Try the soft reset first and if that doesn’t do the trick, try a hard reset. If the problem persists, speak with your data specialist about possible resolutions.

- **Soft Reset:** A soft reset gives the Juno a fresh start, similar to rebooting a computer. A soft reset saves data, closes all open applications, and then restarts the handheld. All data and settings are retained after a soft reset, so no restore is needed. To perform the Reset, use the tip of the stylus to lightly press the reset button.

- **Hard Reset:** Do not perform a hard reset unless a soft reset does not solve the problem. A Hard reset erases all data, installed applications, and settings stored in the handheld, except for any data or applications that were pre-installed on the handheld or are stored on a memory card. To perform a Hard Reset, press and hold the power button at the same time you lightly press the reset button with your stylus. After this, hold the Power button and both Soft Keys to turn the device back on. You will briefly see a message "Hive Clean" before the device resets to factory defaults.
Objective 2: Built-In GPS settings

The GPS settings are already set on each Juno when the device is loaded with Pendragon forms. However, if the GPS is not working or is having problems making GPS grabs, use the following procedure to verify that the settings on your Juno are correct.

- Press and select GPS Controller. In the top left corner of the screen, there is a drop-down menu. Press the menu and select “Setup” to begin.

- In Setup there will be two options, one for GPS Settings, and one for Real-Time Settings. Press GPS Settings. In GPS Settings, the drop-down menu should read “COM4:GPS”.

- Use the scroll bar on the right of the screen to scroll down to NMEA Output. Use the drop-down menu to select “ON”. A Wrench Icon will appear that will allow you to adjust the NMEA Output settings. Press the Wrench Icon, scroll down to the RMC option, and make sure it is checked. Press OK until you are back at the Setup page.
In the Setup screen, Press Real-Time Settings. In the “Choice 1” drop-down menu, select Integrated SBAS. “Choice 2” will appear as will the Wrench Icon, but since no other settings need to be changed, Press OK.

In the GPS Controller drop-down menu, select “Skyplot” to get out of the Setup screen and view the satellites being picked up by the device. You are finished setting up the built-in GPS.
Objective 3: Built-In Camera settings

1. Parts of the Camera and Taking a Picture

   - Press the Camera Button on the right side of the device to start the Camera application. By default, the Camera application starts in image capture mode. Use the Zoom button to adjust the magnification of your image before taking your photo. To capture an image, point the Camera at the object, and press the Camera button. Because the Camera has autofocus, there will be a slight delay after depressing the Camera button. Continue to hold the Camera still until you hear the “click.”

2. Adjusting Camera Settings

   - To access the Camera settings, tap the screen while in the Camera application

   - The Camera’s current settings are displayed as icons on the screen. Tap the required icon to change its setting. The settings will stay the same whether you are in Image mode or Video mode. Press the image capture icon in the settings to change from image capture to video capture. When taking an image or video make sure that the file storage location is "MicroSD card" and not "Device memory". The default image settings you will use are highlighted in red below. To exit out of Camera settings, tap the screen or press the Camera button.
<table>
<thead>
<tr>
<th>Camera mode</th>
<th>Setting</th>
<th>Icon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image and video</td>
<td>Exit Camera application</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>Image and Video</td>
<td>Operating mode</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>Image and Video</td>
<td>File storage location</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>Image and Video</td>
<td>Resolution</td>
<td><img src="image" alt="Icon" /></td>
</tr>
</tbody>
</table>

*Video only allows 320x240 to be selected

Note - The larger the resolution, the larger the file size. Taking a picture with a larger resolution may take longer to capture; continue to hold the camera button until you hear the ‘click’.

<table>
<thead>
<tr>
<th>Camera mode</th>
<th>Setting</th>
<th>Icon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image and Video</td>
<td>White balance. Set according to user environment to ensure accurate image color.</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>Image and Video</td>
<td>Exposure</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>Image and Video</td>
<td>Brightness adjustment. Select plus numbers to lighten the image, select minus numbers to darken the image.</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>Image</td>
<td>Image review</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>Image</td>
<td>Quality adjustment</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>Image</td>
<td>Focus</td>
<td><img src="image" alt="Icon" /></td>
</tr>
<tr>
<td>Video</td>
<td>Mute</td>
<td><img src="image" alt="Icon" /></td>
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</table>
5. LINE DISTANCE PROTOCOLS

The goal of conducting line-distance surveys is to acquire an unbiased estimate of the density and abundance of desert tortoises. Achieving this requires integration of various field activities, but most directly it requires the ability to define the transect, locate tortoises, and accurately measure the distance from the transect to the tortoise. Two types of practice arenas are used to assess your ability to successfully achieve these goals: 1) a model population of desert tortoises (“styrotorts”) is utilized for training and testing on detection and measurement, and 2) practice transects are walked in the Large-Scale Translocation Site (LSTS) near Jean, Nevada.

Desert tortoise monitoring using distance sampling requires that distance from the transect line to live tortoises and carcasses be accurately measured. Surveyors walk transects at specified locations on predetermined bearings. When a tortoise or carcass is observed you must 1) use a compass to determine the local transect bearing (this may be different from the predetermined bearing), 2) use a compass to determine the bearing (azimuth) from the point of observation to the tortoise or carcass, and 3) measure the distance to the tortoise or carcass using a measuring tape. These data are used to calculate the distance from the observed tortoise or carcass to the local transect line. Accuracy and precision in these measurements are critical for adequate estimates of tortoise density.

Tortoises are not active and visible consistently throughout the day. For this reason, the timing of transect completion must be coordinated with optimum tortoise activity periods. These periods will change over the course of the many weeks of monitoring, and teams are responsible for matching their transect start times to these shifting windows. Each day of the field season, all transect teams are maintaining start times and distance sampling protocols that must be consistent with all other transect teams. They must also coordinate their activity with telemetry crews who collect information on the proportion of tortoises that might not have been visible even during the optimum time of day.

Refer to Appendix I for paper data sheets and description of fields.

Objective 1: Crews will apply the search technique as trained so that tortoise detection probabilities and densities are accurately estimated.

Metrics: Data collected by each team on tortoise models will be used to evaluate
1) Detection functions. These must reflect proper search technique by demonstrating consistent, high detection rates on the transect line out to about 2 m, with declining detection rates beyond this.
2) Accurate tortoise abundance estimates. Each team’s estimates of abundance must include the true value within the 95% confidence interval.
3) Detection on the line. Dual-observer teams will detect close to 100% of all models within 2 m of the transect center line. Leader-only detections will be over 80%.

Detection curves for teams of crews will also be reviewed and assessed on a weekly basis during the field season.
Objective 2: Each team will complete transects in the prescribed fashion within specified time limits, including start time and minimum total time.

**Metrics:** On practice transects, crews will demonstrate ability to navigate to start points by the preplanned time, and will complete full transects each day, moving at a sufficiently slow pace so that tortoise detection is not compromised. These metrics will also be assessed for each team on a weekly basis during the field season. On a daily basis, transect crews will communicate their transect completion times to telemetry crews so that scheduling of transects and radio-tracking can be coordinated.

Objective 3: Each crew member will accurately and precisely measure the local bearing of a transect, and the azimuth and distance from the point of initial observation to a tortoise/carcass.

**Metric:** Perpendicular distances of tortoise models to the transect center line should be estimated to within 10% of the known value and without significant bias.

Objective 4: Crews will correctly implement distance sampling protocols for desert tortoises on standard transects.

**Metric:** On practice transects, crews will demonstrate ability to implement the set of guidelines for standard transects, appropriately collecting and entering data on paper and electronic forms. These metrics will also be assessed for each team on a weekly basis during the field season.

Objective 5: Crews will appropriately implement techniques to walk non-standard transects when obstacles prevent completion of planned standard paths.

**Metric:** On practice transects, crews will demonstrate ability to implement the set of guidelines for non-standard transects, appropriately modifying the transect and documenting changes on paper and electronic forms. These metrics will also be assessed for each team on a weekly basis during the field season.
METHODS

Objective 1: Apply the Search and Detection Technique

This objective will be the emphasis of training in the arenas with tortoise models. See [Chapter 1:] Distance Sampling and Desert Tortoises for description of detection functions that result from correct implementation of search techniques. See objective 4 (below) for description of the protocol applied to standard transects.

Objective 2: Start and Complete Transects to Optimize Tortoise Detections

Optimizing monitoring to coincide with tortoise activity

One adaptation that tortoises have for living in the desert is to restrict surface activity to fairly narrow windows of time during the year. In general, tortoises predictably emerge from deep within shelters (burrows) from mid-March through mid-May and then again (less predictably) in the fall. These periods coincide with flowering of their preferred food plants (in spring) and with annual mating cycles (in fall). The range-wide monitoring effort is scheduled to match the spring activity period for tortoises.

During this season, not all tortoises are above ground or visible in burrows. To encounter as many tortoises as possible, monitoring is scheduled to be completed before the hottest time of day. Because we are finding tortoises by sight, monitoring is restricted to daylight hours. Based on past experience, we expect tortoises to become most active after 8 am at the beginning of April, but to emerge earlier and earlier until their daylight optimal activity period is closer to sunrise by mid-May. In May, we also expect daytime temperatures to limit tortoise above-ground activity as the morning progresses to afternoon.

Field crews should complete transects during this optimal period each day. Start times are decided in advance, and crews should arrive at their starting waypoints at similar times on a given morning. Start times are arranged each week between the field crew leaders and USFWS. However, completion times will be more variable, and will be affected by terrain, air temperature, number of tortoises encountered, etc.

Although we have general expectations about when tortoises are most active each day, and indeed have expectations of the proportion that will be active, density estimates are corrected using real-time information about tortoise visibility during the actual periods tortoises are counted. The role of telemetry crews is to provide these activity descriptions (=estimates of $G_0$).

$G_0$ graphics are presented in Fig. 5-1. Note that the proportion of radio-tracked tortoises is most consistent and highest in the second week of the field season at this site (Fig. 5-4). Activity was depressed early in the morning earlier in the field season and there is overall lower activity by the end of the field season, especially in the afternoon. Note that even though they may be “visible,” you may be cautioned that tortoises are harder to find (visible but more concealed in burrows or vegetation) earlier in the day in April or later in the day in May. Crews should remember that after emerging for daily activity, tortoise may withdraw to less visible above-ground locations.
Telemetry and transect crews are responsible for beginning the field day at the scheduled time. For transect crews, the field day begins at Waypoint 1. For telemetry crews it starts with the first behavior observation of a transmittered tortoise. Each field group will use their own method to communicate between transect and telemetry crews so that telemetry crews monitor until all transects have been completed for the day.

![Figure 5-1](image-url)

**Figure 5-1.** Proportion of tortoises at the Coyote Springs G site that were scored “visible” after detection by radio receiver. Observations are graphed separately for each week and plotted for every other week of the monitoring season.

**Objective 3: Measure the Local Bearing of a Transect and the Azimuth and Radial Distance to each Tortoise**

When a tortoise or carcass is found, after taking the local bearing (from the observer back to the other end of the 25-m cord), record the azimuth (bearing from observer to tortoise) and finally the distance from the observer to the tortoise (the radial distance, $r$). Radial distances are recorded to the nearest 0.1 m. The database will calculate the perpendicular distance automatically (Fig. 5-2). Ideally, the bearing of the 25-m line should be close to the transect bearing, but the detection function must be developed using distance from the traversed line, not from the ideal line. In the example illustrated in Fig. 5-2, the intended transect path would have passed 6.4 m from the tortoise, whereas the local bearing determined from the 25-m line resulted in an actual perpendicular distance of 7.7 m.
Figure 5-2. Schematic of position data collected to determine the perpendicular distance from a tortoise to the transect. The perpendicular distance, \(d\), will be calculated automatically by the forms program in the Juno.

Occasionally, a tortoise or carcass will be located behind the end of the 25-m line. In general, measure the azimuth and distance from the end of the line that is closest.

If a tortoise or carcass is detected between the ends of the 25-m line, perpendicular distance can be measured directly to the transect line on the ground. It is important to confirm that you are measuring the path at 90° from the line, but taking both the local bearing and azimuth would potentially add more measurement error. Instead, enter the [intended] transect bearing as the local bearing, enter a 90° azimuth to the transect bearing while also confirming this path to the line, and enter the perpendicular distance to the line as the radial distance. Check that the calculated perpendicular distance given by the Juno is the same value as the radial distance you measured. Inaccuracies can also arise if the tortoise is detected only a couple meters in front of the 25-m line. In this case, continue walking the current bearing until the perpendicular distance can be measured to the tortoise using the simpler and less error-prone method above. In all other circumstances, use the 3-measurement method to estimate the perpendicular distance because movement by observers after an object (tortoise) is detected has been shown for other projects to add bias to density estimates.

Objective 4: Implement Appropriate Techniques for Standard Transects

Monitoring strata are typically a combination of Desert Wildlife Management Areas and USFWS Critical Habitat. A systematic design is used to place transects within strata. Standard transects
for range-wide monitoring are 12 km long, comprising 24 500-m segments. The standard transect forms a square with 3-km sides (Fig 5-3A). If there are sufficient square transects in a stratum, they will occasionally intersect. A transect’s starting point should be based on the location that is most efficient to access by vehicle (Fig. 5-3B). However, it is desirable to maintain segment lengths (the distance between waypoints) at 500 m, so the start point should be a multiple of 500 m from the first corner that will be encountered (Fig. 5-3C). Determining the best car-entry point for each transect requires planning and map work before the transect is walked. Spatial files of the planned transects have been provided to GIS specialists for each field team, and have been used to plan access to transects and whether the transect is expected to be completed as a standard 12-km square. Once the starting point is located and initial data (transect number, crew information, etc.) are collected, the transect is walked according to the following procedure. Note that all bearings are with reference to true north, so all compasses must be adjusted for appropriate declination.

- Under normal conditions, you and a partner will walk one 12km square transect each day. You will be paired before training begins, and should remain partners throughout the field season. Partners alternate lead and follow positions at each corner of each transect, each person spending an equal amount of time in the leader and follower positions. The first leader each day should be the person who finished the previous day (transect) as follower.
- Using a compass adjusted for declination, you will start walking on the designated bearing, pulling a 25-m length of durable line. The walked path becomes the centerline of the transect. While it is pulled, the line helps the follower report to the leader on whether the transect is on course; when the line is placed on the ground after a tortoise or carcass is detected, the line facilitates measurement of the local transect bearing. The walked length of each transect is calculated as the straight-line distance between GPS point coordinates that are recorded along the transect (waypoints). Therefore, it is important to
walk a straight line between waypoints, using reference to the compass, a sighted point on the horizon, and the trailing line. The line should be passed over the top or directly through shrubs or trees that lie in the transect path, attaching the line to a staff if necessary. Waypoints are recorded at 500-m intervals and at corners where the transect turns. The leader maintains the correct bearing and is responsible for determining the correct length of each leg of the transect.

- The follower will trail the leader at the end of the 25-m line. Both leader and follower scan for tortoises independently, and the role of the crew member finding each tortoise is recorded in the data. Although the leader will see most of the tortoises, it is intended that the follower will see all the remaining tortoises near the centerline, so this role is crucial to unbiased estimation of tortoise densities. The follower will also notify the leader if the transect is deviating from the designated bearing.

- The leader progresses along the transect, scanning the ground for tortoises or carcasses.

All 3 examples assume the same location of the southwest corner (orange dot). Waypoint numbers are indicated sequentially (A), from the starting waypoint (1) to the ending point (99). Waypoints are spaced approximately 500 m apart and any planned waypoint can serve as a starting point, depending on the access point. In (B), the optimal access point (closest road access, usually waypoints 0 and 100) is the northeast corner. Transects can also be accessed at sides. Note that in (C) although the closest access point is on the transect, waypoint 1 (the starting point) is south of this to maintain 500-m segments.
Concentrate on scanning the ground in a radius of about 5 m and as far out as 10 m. Little time should be spent scanning the horizon (except as necessary to maintain a consistent bearing) or scanning right around one’s feet.

Special attention should be paid to searching vegetation intersected by the transect.

If it is necessary to leave the transect path to investigate a burrow or suspected tortoise or carcass more closely, the leader should drop the end of the line in place, so that the transect path remains unambiguous.

Attention should be given to ensuring the transect line does not “drift” toward a tortoise when one is observed. Tortoise density estimates would be biased if the transect consistently bends toward tortoises.

The follower uses the same search technique as the leader. It is important that both crew members are searching for tortoises in the same manner.

If the leader stops to investigate a burrow, the follower should also stop to maintain position at the end of the 25-m line.

Likewise, if the follower needs to investigate a burrow or suspected tortoise, the leader should stop while this is taking place.

When a 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. Electronic data collection reduces data entry and transcription errors, but is not foolproof. Paper sheets are independent versions of data on the electronic data forms, not backup data. It is essential to take accurate data, and to complete each section of the data sheet in both paper and electronic forms before moving ahead. Refer to Desert Tortoise Handling for details on proper handling and measurement techniques.

Ideally, when a tortoise or carcass is found the bearing of the 25-m line should be close to the transect bearing, but the detection function must be developed using distance from the traversed line, not from the intended line. In all cases when the transect has been paused, the recheck the bearing of the transect. Resume walking on the measured local bearing (after recording a tortoise) or on the original planned transect bearing (from a waypoint).

In addition to tortoise data, crew members will collect waypoints at regular 500-m intervals, or more frequently if a corner or interruption is needed (Implementing Protocols for Non-Standard Transects, below).

If an existing tag or marks are present they should be recorded. Various identifying techniques have been used on tortoises for other projects, and the database is equipped to record identifying information from these marks. Crews may need to clean the tags to make them legible, and should have any necessary reading gear with them; the numbers are small and will otherwise be difficult to read. If no tag is present, a tag should be applied.

If a tortoise is in a burrow and cannot be removed, it is nonetheless important to record whether unhandled tortoises are adults at least 180 mm MCL or subadults.

When at least half of a tortoise carapace is located, or if any carapace with identifying marks is located, the necessary data fields will be completed. Shell remains persist for a number of years in the Mojave Desert.

Tortoises or carcasses located anywhere in the course of a transect day (between the vehicle (waypoint 0) and return-to-vehicle point (waypoint 100) but without using the distance searching protocol should be recorded using the “opportunistic” tortoise and carcass forms.

GPS coordinates must be collected at all waypoints, tortoise, and carcass locations. If an automated GPS grab is not possible, UTM coordinates will be entered manually.
Occasionally, transects will encounter obstacles that make it impossible to complete a standard transect. Paved roads with light traffic and rail lines should be crossed safely without interrupting the transect. Obstacles that should lead to changes in the transect path include major highways (e.g., all Interstate highways, US Highway 95 and 395, and California Highway 58), hazardous rock formations, or hills or washes too steep for safe navigation. When such obstacles are encountered, the transect path should be adjusted according to Implementing Protocols for Non-Standard Transects, below.

Additional documentation for range-wide monitoring on paper data forms
The electronic and paper data forms are carefully matched to have the same fields and collect the same information. The exception is that paper data forms are also designed to collect information about how each transect was completed. Information on access routes, including GPS locations for important intersections, can be written long-hand on the paper data forms. These forms also have an area to sketch the transect as you completed it. Please indicate all waypoints, numbering 0, 1, 99, and 100. Also indicate roughly where any obstacles, tortoises or carcasses were encountered along the transect. These sketches can be used in the future to indicate access points, and in this season to clarify potentially misleading information such as inaccurate GPS grabs.

Objective 5: Implementing Protocols for Non-Standard Transects

Each monitoring transect is associated with a “sampling stratum.” For analysis, all data from all kilometers walked in a stratum are combined, and the analysis proceeds from there. If we only walked transects in mountains, we should only relate our analysis to mountainous areas of the stratum; if we only walked transects in flat areas, our estimates of tortoise density only apply to flat areas. Instead, each stratum has different terrains, topographies, vegetation types, and substrates. We are pretty sure that each of these attributes affects the density of tortoises, so to apply our tortoise density estimates to the entire stratum, we need proportional, representative sampling across the varieties of habitats that are available.

Avoiding human infrastructure and administrative boundaries (12-km transects)
To sample stratum edges, we include some transects that would also cross out of stratum and into adjacent lands. Before walking these transects, the “outside” portion is pulled into the stratum so that the path walked is the same distance from the stratum boundary, but is now inside. There are other cases in which the landscape and the transect are intersected by human structures such as signed properties that prohibit access, or by major highways. (Roads with light traffic and railroads can be safely crossed as part of a standard transect.)

Transects should be rebuilt appropriately before the field season to move inside stratum boundaries and to one side of other identified obstacles listed above. Some structures are not indicated on our planning maps, so crews should understand the rules below and how to apply them when these situations arise unexpectedly. The figures below illustrate how to reflect a planned transect based on where a boundary (or fence that prohibits access, or interstate highway) intersects the transect. There are different approaches depending on whether a single corner is outside the boundary (Fig. 5-4), the boundary crosses at an oblique angle and excludes 2 corners (Fig 5-5), or it crosses parallel to one of the sides, excluding 2 corners (Fig. 5-6). Applying 5-6 is also a simpler option for the unplanned situation in 5-5 when it is encountered.
The planned transect (dotted square) is reflected inside the boundary (blue line) to create a new transect (red line). Crews must be given distances “a” and “b” before starting, or must measure these themselves based on the easting and northing at Point A and at the corner before it (here, the northeast corner). The length of a side, $\ell$, is usually 3000 m. Crews reorient at A, B, and C.

The planned transect (dotted square) is reflected inside the boundary (blue line) to create a new transect (red line). Crews must be given maps or planning materials with distances “a” and “b” before starting, as well as their new bearing at Point A. Crews reorient at A, B, C, and D.

The planned transect (dotted square) is reflected inside the boundary (blue line) to create a new transect (red line). Crews must be given distance “a” before starting. At Point A, they will reorient 30° south or west if the transect is odd-numbered. For the obstacle crossing from north to south in this example, the crew would walk south. They would reorient west for a boundary crossing east-to-west. (Crews reorient north or east if the transect is even-numbered.) Corresponding shifts must be implemented at Points B, C, and D.
Sampling through rugged terrain

We would prefer for all transects to be walked exactly as they are selected so that we are confident of the applicability of our tortoise density estimates to the entire stratum. However, there are limits to what can reasonably be sampled. In particular, crews must return safely and be able to rest sufficiently to work safely the next day as well. As a rough guide, crews should evaluate their ability to return to their vehicles by 4 pm each day. The following material describes the types of changes that will be implemented in rugged terrain to modify standard transects or those already restructured to avoid human-built boundaries (Figs. 5-4 to 5-6).

The transect is partially or entirely intersected by rugged terrain or unstable substrate

This can usually be determined before attempting the transect, although deeply incised washes or large stretches of unstable substrate may not be obvious until the crew has started the transect.

- Is it interrupted by a very short but severe obstacle? Some transects cross a ravine or other relatively short, steep area. When small obstacles occur on a transect, crews can use a short scramble (~20-30m) to get up or over something, look really hard before scrambling, turn around and look really hard again. The lead scrambles up with the line, the follow stays at the bottom. After the line has been examined by both the lead and the follow, the follow scrambles up to meet the lead and the line is resumed as normal. The transect follows the regular assigned path. It is not a standard transect, but it is also not a “shortened” transect.

- Is it interrupted by severe obstacle like a cliff? When more than 500 m of the planned route is not traversable, you should shorten the transect.

  o Internal interruptions – If you have completed some of the transect and a continuation of the transect is possible after you navigate the obstacle, enter a waypoint to interrupt the transect, find a safe route around the obstacle, and resume the transect at the point where it can once again be navigated (Fig. 5-7). The same path is sampled as for the standard transect, interrupting as needed to avoid areas of non-traversable terrain. This is also a non-standard transect, and it has been shortened.

Figure 5-7. Interrupting a transect to move around a barrier. This diagram uses transect and waypoint numbers to match the example that follows.

The planned transect (dotted square) crosses an impassable obstacle such as a cliff (yellow line). The walked transect (red line) is ended with a waypoint at the obstacle, but Waypoint 99 is NOT used. A new transect (green line) is started after navigating around the obstacle. Transect 42.1 starts with Waypoint 9, continuing the series of waypoints from Transect 42. Waypoint 99 is only used in the last segment (in this case, the end of Transect 42.1).
• Is it covered by more than a few hundred meters of un-navigable terrain? Shorten the transect along the original path, (Fig. 5-8). In this case, there are no internal interruptions, just one continuous but shortened transect. The transect is not standard, and it has been shortened.

• If even a shortened transect is not possible, do not attempt the transect.

Figure 5-8. Shortening a transect when the planned 12-km version is too rugged.

The planned transect (dotted square) traverses impassable terrain or is through passable terrain but at such a slow pace that it cannot be completed before 4 pm. Consider a shortened version of the transect instead, following the original path and using interruptions to avoid impassable terrain (red line). This approach should be used when it is anticipated that at least 6 km of the original 12-km path will be sampled. Crews may also need to further shorten the transect in order to return to their vehicles by 4 pm.

The transect must be accessed by hiking in for several kilometers

On-foot access increases either the time-to-transect in the morning, or the time-to-vehicle in the afternoon. Consider whether the transect can be completed as planned or shortened as appropriate. If a crew cannot access and complete the transect, then return to the vehicle by 4 pm, do not attempt the transect. One exception to this is if the field team uses base-camping to provision remote access of one or more transects. There is no “penalty” for returning to the vehicle after 4 pm; this is simply a guideline for handling inaccessible and/or rugged terrain.

Use appropriate documentation for non-standard transects.

• At each point where a turn is made for a reflection, a waypoint should be recorded. At the points where a transect is interrupted and then restarted, waypoints should be recorded. Waypoints should be no more than 500 m apart, and can be much closer together as needed on non-standard transects. Each waypoint subform includes a field to communicate whether the transect is interrupted at this waypoint, as well as a field for comments, and it is appropriate to note the start of a reflection or transect shape change in this field. The numbers of waypoints are tracked on your sketch of each transect; the sketch and associated waypoint numbering for non-standard transects is particularly important.

• When all waypoints on a transect are completed, the Juno will return you to the transect description section of the transect form. You will be asked whether the transect was walked as a standard transect, 12 km long with 3-km sides. All other shapes and lengths are not standard. Interrupted transects are not standard.
- For non-standard transects, you will identify the types of obstacles (terrain, substrate, other) that led you to modify the transect. Use the “other” field when a transect was modified to avoid an administrative boundary (e.g. stratum edge) or an uncrossable highway. If a transect has been pre-reflected, crews should know why before going into the field. If the transect was not pre-reflected, use the “unplanned_modification” field to indicate this. Unplanned modifications might occur due to new private fencing, construction, or mining activity.

**Additional documentation on paper data forms**
The electronic and paper data forms are carefully matched to have the same fields, although paper data forms are also used to collect information about how each transect was completed. Information on access routes, including GPS locations for important intersections, can be written on the paper data forms and there is an area to sketch the transect as you completed it. Indicate all waypoints, numbering 0, 1, 99, and 100. Also indicate roughly where any obstacles, tortoises or carcasses were encountered along the transect. These sketches provide information for future access and clarify potentially misleading information such as inaccurate GPS grabs.

**Using two or more transect forms to collect data on one interrupted transect**
Normally, we assume that waypoints plot the continuous path walked on a transect, so if a transect is interrupted internally (Fig. 5-7), use the “comment” and “end_part” fields to indicate that you are interrupting the search at this waypoint. You must also end the electronic transect form at this waypoint. Once the obstacle is navigated, begin a new transect form, with the new transect number equal to the original number plus “0.1”. If the original transect was 42, for instance, the transect number for the section after the obstacle would be 42.1. If a subsequent interruption is required, a new transect would be created and designated as 42.2.

Treating the walkable parts as separate transects is an important bookkeeping device for data processing. A few things will be different from a standard transect though. Instead of beginning with Waypoint 1, waypoint numbers will continue in sequence through all transect segments. For example, if the last waypoint recorded on transect 42 was 8, the start waypoint for transect 42.1 will be 9. In the case of using multiple transect forms to document a single interrupted transect, only the final transect form will end with Waypoints 99 and 100. In this example, if you have transects 42, 42.1, and 42.2, only the completed transect 42.2 will have a Waypoint 99 or 100. Waypoint 0 (drop off) will only be recorded for transect 42.

Record all transect or opportunistic observations of tortoises or carcasses under the transect part where they were found. The first transect records will indicate “tran_standard=N”, and will describe obstacles that shortened that segment. The final segment may indicate “trans_standard=Y” or “tran_standard=N,” depending on whether it ends as planned, or at an obstacle. As with waypoints, observations are numbered continuously through all parts of the transect; do not start counting again from “1” when you start a new transect part.

In summary, although the waypoint and observation numbers continue in sequence through all parts of the interrupted transect, all transect parts will have their own transect number, will hold their own observations, will describe obstacles unique to that segment, and will have their own transect form on the Juno. However, a single set of paper data sheets is used to document all parts of the transect. At the appropriate waypoints, write in the new transect number used in the
electronic form, and on the transect drawing, indicate where the interruptions occurred and new transect numbers were instituted.

EXAMPLE – electronic form

Transect 42
Waypoints 0, 1, 2, 3, 4, 5, 6, 7, and 8
At waypoint 8, end_part = Yes
0 transect live observations
2 transect carcass observations, numbered 1 and 2
1 opportunistic live observation, numbered 1
1 opportunistic carcass observation, numbered 1
Waypoint 1 time 7:00am
End the transect record using tran_standard=No and provide the list of obstacles.

Transect 42.1
Waypoints 9, 10, 11, 12, and 13.
At waypoint 13, end_part = Yes
1 transect live observation, numbered 1
1 transect carcass observation, numbered 3 to follow those in transect 42
0 opportunistic live observations
0 opportunistic carcass observations
End the transect record using tran_standard=No and provide the list of obstacles.

Transect 42.2
Waypoints 14, 15, 99, and 100.
0 transect live observations
1 transect carcass observation, numbered 4 to follow the one in transect 42.1
0 opportunistic live observations
1 opportunistic carcass observation, numbered 2
Waypoint 99 time 3:22 pm, end_part = No
End the transect record, enter tran_standard=Yes
All other regularly recorded transect information.

EXAMPLE – paper form

Transect 42
Waypoints 0 to 15, 99, and 100.
In the comment for Waypoints 8 and 13, indicate an interruption initiated.
In the comment for Waypoints 9 and 14, indicate Tran_num 42.1 or 42.2, respectively.
1 transect live observation
4 transect carcass observations, numbered consecutively.
1 opportunistic live observation
2 opportunistic carcass observations, numbered consecutively.
Transect Start time 7:00 am
Transect End Time 3:22 pm
A single transect sketch indicating all waypoints and observations, plus “42.1” and “42.2” written next to the waypoints where each new electronic form was started.
6. RADIO TELEMETRY AND G0 PROTOCOLS

Across the Mojave Desert, several small groups of 8-12 tortoises each have been equipped with radio transmitters and are used to estimate the proportion of tortoises in the local area that are active/visible. Individuals are observed repeatedly throughout the day using a VHF radio receiver and a directional antenna. Each time a tortoise is located, data are recorded indicating its visibility on the surface, in a burrow, or in vegetation. These data allow us to calibrate distance sampling results to account for the proportion of the population that eludes sampling due to fossorial or cryptic behavior. The radio-equipped tortoises are called G0 tortoises (“gee-sub-zero”) for the mathematical term in the density equation that represents tortoise availability.

The primary goal of G0 training is successful implementation of the G0 protocol by telemetry crews. This includes correct use of telemetry equipment, understanding G0 data collection fields, observation of as many radio-equipped tortoises as possible during the day, observing the appropriate focal population for the transects being sampled, and a window of observation that overlaps the day’s transect time window for each sampling area. An additional goal is to make related work on transects more understandable to line distance crews.

Objective 1: Locate tortoises and collect activity data.

Standard: G0 monitors will be proficient in using telemetry equipment to locate tortoises. Standard: G0 monitors will be proficient at collecting appropriate data.

Metric: G0 monitors will use telemetry equipment to locate radio-equipped tortoises and will complete site-day and observation forms correctly. They will demonstrate correct operation of VHF radio receivers. When a tortoise is not immediately detected with a receiver, they will apply appropriate troubleshooting procedures to locate the tortoise.

Refer to Appendix I for paper data sheets.

Objective 2: Implement the daily G0 protocol.

Standard: G0 monitors will successfully complete daily monitoring activities related to schedule coordination with line distance crews and with one another to collect sufficient daily observations on each tortoise.

Metrics: At an actual G0 site, monitors will locate and record G0 data at a rate equivalent to that required to sample 10 tortoises at least 3 times a day (the length of which is defined by the time between typical start and end times for transect monitoring), and bounding the transect sample period as assigned by trainers. G0 monitors will coordinate with their team leaders to schedule their activities while data are collected on transects.
Objective 1: Locate Tortoises and Collect Activity Data

Contents:

1. Definitions
2. Equipment
   a. Transmitter
   b. Antenna
   c. Receiver
3. Procedure
   a. Preparation
   b. Tracking
   c. Detection
4. Troubleshooting
   a. Technique
   b. Signal Reflection
   c. Signal Drift
1. Definitions

- **Radio Telemetry** involves data transmission over a distance. In this case, the observer uses a receiver to detect a signal emitted from a transmitter attached to a desert tortoise.

- A **Radio Transmitter** radiates a regularly timed signal at a very specific frequency.

- The **Frequency** is built into the battery-powered transmitter and is a specific band within the electro-magnetic spectrum (in this situation 164-168 MHz).

- Approximately once per second, the transmitter emits a “beep” at one precise frequency; this **Signal** travels in a wave over a specific distance (its **Range**). To detect this signal, the observer needs to be within this range (generally 500 - 900 meters).

- The transmitter signal’s frequency is not auditory to humans. Thus a radio **Receiver** is used, allowing the observer to hear the signal when s/he sets the correct frequency into the receiving unit.

- The **Directional Antenna** boosts the receiving power and, because it is tuned to be loudest in only one direction, allows the observer to follow the sound to the signal’s source.

- Increasing **Gain** increases the receiving unit’s amplification of the signal, but sometimes also increases noise. The gain differs from **Volume**, which only changes the noise intensity coming from the receiver's speaker.

2. Equipment

The equipment used to conduct radio telemetry on desert tortoises is typical of that used on many types of animals. The distance from which a signal can be detected is a result of many interacting factors involving the power of the transmitter, the quality of the receiver and the specificity and gain of the receiving antenna. In addition, your ability to track will be influenced by outside factors such as climate, terrain, and obstructions or interfering structures (e.g. power lines).

**Transmitter:**

Many tortoises in the Mojave Desert are subjects of research or monitoring programs and carry a radio transmitter. Comprising the transmitter are a battery, a frequency emitter, and a
whip antenna. While size, design and location on the tortoise may vary, the transmitter’s basic operation remains the same.

Epoxy binds the transmitter to a scute (segment) on the tortoise’s carapace (shell). The whip antenna is affixed to one or more scutes as an additional measure to prevent the transmitter’s accidental removal. In the event that this antenna is damaged or severed, the tracking range becomes severely limited, typically less than 50 meters. While this antenna may be completely attached, more commonly it extends loosely behind the tortoise, reducing the epoxy mass and making the unit less cumbersome (see Figure 1).

Figure 1. Examples of typical VHF transmitter attachment to desert tortoises.

Transmitters currently in use for LDS broadcast in the VHF frequency range, between 164-168 megahertz (MHz). Each tortoise has a unique frequency, for example, one tortoise may have the frequency 164.236. Yet the signal will “bleed” into neighboring frequencies, so this tortoise may be heard at 164.234 or even 164.238 depending on the transmitter’s accuracy and the receiver type. Nearby tortoises must possess sufficiently dispersed frequencies (i.e. 20 or more Hz) to ensure the ability to track the correct tortoise.

**Antenna:**

A directional antenna amplifies the signal from a transmitter and allows the observer to aim toward the source. Commonly, the “H” shaped 2- element Yagi antenna (Telonics RA-2AK) is used, but other multi-element Yagi antennas exist. Each antenna is specifically tuned to a 2K MHz range of frequencies (e.g. 164-166 for the antenna in Figure 2), but may also receive frequencies outside of this range, albeit with lower efficiency.

*These fragile antennas are costly and should be treated with care.* The two-element Yagi depicted in Figure 2 requires assembly, while other models may unfold into the correct operating configuration. For the H-style Yagi, each “kit” should include the main body (A), the arms (B and C) and the handle (D). The arms vary in length and must connect into the correct port on the antenna body. The yellow colored tape on the arms matches that on the body. When assembled, the shorter arms screw into the antenna’s forward portion.
Figure 2. Telonics RA-2AK VHF 2 element Yagi antenna.

A small sticker on the antenna body indicates the “front” (the part to point toward the transmitter) and generally is where the antenna cable attaches. A coaxial cable with BNC connectors on both ends connects the telemetry receiver to the antenna.

_Each crew should carry an operational spare cable in the event that the first fails._
Receiver:

Telemetry receivers are radios capable of receiving in the VHF bandwidth. Several companies manufacture receivers specifically used for telemetry (e.g. Telonics, ATS, Lotek, etc.), but other multi-band receivers can be used as well (e.g. Icom). Technical specifications and control layout differ among various receivers, but similar concepts govern their operation.

The tracker enters the tortoise’s individual frequency into either a number pad or a series of dials. Some models require entry of all six digits (XXX.XXX) to enter the frequency, while others require the entry of only a portion of the whole frequency (e.g. X.XX) where another knob or button adjusts the frequency by small increments (usually 0.001 MHz, or 1 KHz). In multi-band receivers, the “Band” or “Mode” button alternates the various modes to AM, FM, WFM, LSB, USB and CW. For tracking, CW mode is often used, but you should track using the band that allows for the best auditory clarity of the signal. The “best” mode for use may change while tracking a tortoise as the distance to the source decreases.

All receivers allow manipulation of both “Volume” and/or “Gain” to tune the directionality and auditory expression of the transmitter signal during tracking. As the tracker approaches the animal or requires additional directionality, reduction in the Gain (and/or the combined Gain and Volume control) aids in the signal’s attenuation.

**Volume** on a receiver matches that on any radio; it simply adjusts the signal’s amplification to the speaker. The tracker need only set the Volume at a comfortable level.

**Gain** refers to the receiver’s amplification of the signal. Increasing Gain increases the distance from which the observer can detect the signal, but it also increases background noise and reduces directionality. Lowering the Gain reduces noise and increases directionality, but also diminishes the signal’s detection range.
Figure 3. Examples of three typical VHF receivers used in radio telemetry. The Icom IC-R10 (top left) is a multi-band VHF receiver, while the Telonics TR-5 (top right) and Telonics TR-2 (bottom) operate in more limited frequency ranges.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Icom IC-R10/R20</th>
<th>Telonics TR-2</th>
<th>Telonics TR-5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Panel</td>
<td>Digital, clear</td>
<td>Dials, intuitive</td>
<td>LCD, Digital, often difficult to read</td>
</tr>
<tr>
<td>Frequency entry</td>
<td>Enter every digit, including the decimal</td>
<td>The 16 is assumed, the four other numbers are then entered in sequence. For the frequency 164.236, you would see 423 on the dials, and the frequency knob would be turned to 6.</td>
<td>Enter every digit including the decimal, and then press enter.</td>
</tr>
<tr>
<td>Knobs / Controls</td>
<td>R-10: The Volume and Gain knob are the same: R-20: The Volume and frequency knob are the same. For both, hold down the button labeled “RF GAIN” until the screen reads “Set RF Gain,” use the knob to adjust Gain. When it says “max” or “10”, press the “RF GAIN” button a second time to return it to Volume or frequency control.</td>
<td>A single knob combines both Gain and Volume, and they cannot be changed separately.</td>
<td>Up/Down arrows allow Gain and frequency changes with a separate knob for Volume.</td>
</tr>
<tr>
<td>Receiving Power</td>
<td>Low (Often need to be within 300-500 meters)</td>
<td>Medium- High (Often need to be within 500-900 meters)</td>
<td>High (Often need to be within 700-900 meters)</td>
</tr>
<tr>
<td>Charge</td>
<td>11 hours</td>
<td>10 hours</td>
<td>&gt;16 hours</td>
</tr>
<tr>
<td>Size</td>
<td>Small 0.32 kg 6 x 14.2 x 3.48 cm</td>
<td>Medium 0.86 kg 11.7 x 5.1 x 18.0 cm</td>
<td>Large 1.2 kg 17.8 x 11.1 x 6.2 cm</td>
</tr>
<tr>
<td>Portability</td>
<td>Handheld or shirt clip</td>
<td>Leather case with shoulder strap</td>
<td>Blue cloth case with shoulder strap</td>
</tr>
<tr>
<td>Recharge</td>
<td>Wall charger</td>
<td>Wall charger</td>
<td>8 AA batteries</td>
</tr>
<tr>
<td>Frequency Band</td>
<td>Extensive, multi-band VHF receiver: SSB, CW, AM, FM, and WFM. 0.150-3304.999 MHz CW: 118.000-146.999 MHz</td>
<td>Limited: SSB and CW 2K or 4K MHz range: set at factory e.g. 164.000-166.999</td>
<td>Limited 4K MHz range: set at factory 163.000-167.999</td>
</tr>
<tr>
<td>Pros</td>
<td>Light, easy to use, relatively inexpensive changeable or rechargeable batteries</td>
<td>Intuitive to use, lightweight, manual frequency scanning accomplished easily</td>
<td>Powerful, water resistant, changeable batteries Freqs can be programmed</td>
</tr>
<tr>
<td>Cons</td>
<td>Limited range, less effective under powerlines, wrong buttons easily pressed, modes confusing</td>
<td>Batteries cannot be changed, recharge only, non-programmable. Gain and volume coupled.</td>
<td>Heavy, difficult to use, display difficult to read, Gain change takes time, frequency adjustment awkward.</td>
</tr>
</tbody>
</table>
3. Procedure

Preparation:
Assemble the necessary equipment:
- GPS
- PDA
- Two-way radio
- Charged receiver
- Yagi antenna
- 2 Coaxial cables
- Sufficient replacement batteries
- A list of past known locations and frequencies for each tortoise
- Mirror
- Compass
- Paper datasheets
- Writing implements
- Safety equipment
- Water

Check the tortoise frequencies and bring the appropriate receiver and antenna prior to heading into the field.

*Never track when lightning may strike.*

Tracking:
1. Follow the provided GPS coordinates to the tortoise’s last known location; start as close as possible to that site.
   (Note: Listening to the tortoise’s frequency while traveling to its last location, and even scanning for other nearby tortoises as well, is recommended. Tortoises move frequently during the activity season, increasing the likelihood that the tortoise you seek will be found in a different location than the last. You will save time if you listen for each animal while traveling between locations.)
2. Assemble the antenna and connect it to the receiver using the coaxial cable.
3. Turn on the receiver and enter the correct frequency.
4. Set Gain to maximum.
5. Listen for the signal:
   a. Stand a few meters away from vehicles or structures.
   b. Hold the antenna high at arm’s length.
   c. Orient the antenna in a Vertical position (see Figure 4). The Vertical orientation provides more range but less directionality.
   d. Listening for the transmitter beep, rotate your body in a slow, *complete* circle.
   e. Determine the direction from which the signal sounds strongest.
6. Follow the signal and adjust:
   a. Walk toward the loudest sound.
   b. Continue listening while walking, sweeping the antenna from side to side to confirm a strong signal directly forward.
   c. If the signal weakens, repeat Step 5 and continue in the new direction.
   d. Reducing Gain while approaching the source also aids in narrowing the loudest signals direction.

7. Improving Directionality:
   a. When you hear the signal clearly (about 300 meters or so), orient the antenna in a Horizontal position (see Figure 4). This provides less range, but better directional certainty. Once you hear the signal using this orientation, the Vertical position becomes unnecessary.
   b. Repeat Step 5 using the Horizontal orientation.
   c. Continue lowering the Gain as you approach the tortoise until the signal sounds loud at minimum Gain.
Detection:
1. Final Location:
   a. When very close, the beeping becomes loud enough to sound distorted and omnidirectional. Continue walking and sweeping until the signal weakens or sounds louder behind you to triangulate to the correct location.
   b. Upon determining a small area with the strongest signal, point the antenna perpendicular to that area and walk in a circle around it to confirm the correct location; this may take time. At close range the signal may sound equally strong directly behind as well as in front of you.
   c. At this point, begin scanning visually for the tortoise or burrows.
2. Burrow:
   a. If the signal seems to emanate from a burrow, make a visual inspection to locate the tortoise. The tortoise may be deep inside; you should use a mirror to reflect sunlight into the burrow.
   b. If the tortoise cannot be seen, two things can be done to detect its exact location: 
      Be careful: do not step on or collapse the burrow while performing these.
         1) Remove the cable and antenna from the receiver. If beeps can still be heard, the tortoise is very close.
         2) You may “fish” for the tortoise. Remove the cable from the antenna, but leave it connected to the receiver. Dangle the antenna over the burrow and move it around to the loudest point – the tortoise’s most likely location. To avoid getting dirt in the BNC connector, do not let the cable bottom touch the ground. 
To avoid stepping on the antenna, place it up high or in a creosote bush.
   c. If you see a tortoise, make sure it is the one you seek by checking for a transmitter and even a tortoise number on a floy tag glued to the shell.
3. Record Location:
   a. Record the Tortoise Number, Frequency, Northing, Easting, Date, Time, Observer, and any other necessary information.
   b. Use your Juno to record required information as well.

4. Troubleshooting

Technique:
Antenna. Understanding the antenna’s performance may assist in tracking the signal. In figure 5, the antenna’s listening pattern, the sound intensity appears loudest when the antenna points directly at the signal’s origination (0 degrees). Backfeed may be heard when the antenna receives a signal from the opposite direction as well. An alternative exists to determine the correct direction when following the loudest signal is not possible. Holding the antenna horizontally, identify the “signal nulls,” or the sections in which the beeping disappears completely, as opposed to the “signal peaks,” while turning in a complete circle. Walking in the direction exactly opposite to the middle of the null areas forms a viable option.
**Figure 5.** The listening footprint for an antenna held horizontally; northward (0°) sets the signal’s source.

**Receiver.** At minimum Gain, the sound may occur at the same intensity from all sides. This phenomenon makes locating the tortoise at close range particularly difficult. Shifting the frequency slightly up or down may provide a difference in beep intensity. Lowering the frequency until a “thump” sounds or raising it until a very high-pitched beep occurs may provide some direction.

**Signal Reflection.** Many factors may distort the signal’s direction including frequencies from other transmitters, complex terrain, powerlines, and even nearby fences or vehicles. In all cases, the tracker should move away from obstructions to allow for open space through which the signal may travel.

**Terrain.** Rocky terrain, hills, washes, cliffs, and even mountains may obscure or redirect signals. Height above the ground, obtained by climbing hills or up to ridge-tops, increases a signal’s range. The signal may be lost when dropping into a canyon or wash. If a signal does become lost, a tracker should climb to a high place near the tortoise’s last known location to listen for the signal or walk the ridge above a canyon while following the sound.

**Echoes.** As some tortoises do tend to live in washes and cliffside caliche caves, echoes may sound louder than the true direction. For example, a tortoise may be on a mountaintop while the tracker walks below, between mountains; rocks may obscure the signal’s source but the echo resonates clearly bouncing off the opposite mountain. In this case, it is best to climb to a higher point and listen.
**Powerlines.** Powerlines distort or mask signals, making them difficult to acquire or follow. The tracker should walk at least 100 m away from the lines to listen. As an aside, some people have received mild electrical shocks while tracking under the lines.

**Burrow Substrate.** The signal may become dampened or distorted if the tortoise rests deep within its burrow. Caliche seems to mask the signal the most, requiring that the tracker be very near to detect the signal or in a direction corresponding with the orientation of the burrow opening. Other substrates may impede the sound as well.

**Signal Drift:**
A transmitter’s frequency may “drift” up or down with changes in climate and over time. Other factors affecting the emitted frequency and transmitted signal include terrain, temperature, humidity, wind speed, the receiver, and the antenna.

If, while in the field, a tracker cannot detect the provided frequency, s/he should first check that the inputted frequency matches that of the desired focal tortoise. When the correct frequency does not yield a signal, the tracker should listen in a complete circle while adjusting the frequency up and down at least 6 KHz away from the original incrementally in both directions. If this does not yield results near the last known location, the tracker may choose to listen from an elevated location, such as a mountain or hilltop. While this may seem like extraneous effort, finding the tortoise immediately represents the best option as it may move even further away if already distant.

Finally, if searching for at least 30 minutes yields no signal, the tracker should proceed to the next tortoise and continue searching for the missing animal while moving among the other animals in the observer’s tracking schedule. This animal may be encountered associated with another as tortoises seem to aggregate at times.

**Objective 2: Implement the Daily Go Protocol**

**Optimizing monitoring to coincide with tortoise activity**
One of the adaptations tortoises have for living in the desert is to restrict surface activity to fairly narrow windows of time during the year. In general, tortoises predictably emerge from deep within shelters (burrows) from mid-March through mid-May and then again (less predictably) in the fall. These periods coincide with flowering of their preferred food plants (in spring) and with annual mating cycles (in fall). Both periods also represent the most likely times to find water in plants or on the surface. The annual range-wide monitoring effort is scheduled to match the spring activity period for tortoises.

During this season, all tortoises are not above ground or visible in burrows. In order to encounter as many tortoises as possible, monitoring is scheduled for early in the day and to be completed before the hottest time of day. Because we are using vision to find tortoises, monitoring is restricted to daylight hours. Based on past experience, we expect 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 until their optimal activity period is around sunrise by the beginning of May. In May, we also expect daytime temperatures to limit tortoise above-ground activity as the morning
progresses to afternoon (see “Line Distance Protocols, Objective 2: Start and Complete Transects to Optimize Tortoise Detections”).

**Coordinating start and end times with transect crews**
Field crews on transects are working to complete transects during this optimal period each day, so crews are likely to arrive at transects at similar times on a given morning. The role of telemetry crews is to provide data to estimate daily tortoise activity during the period when transects are walked. Telemetry and transect crews are responsible for beginning the field day at the scheduled time. However, completion times will be more variable, and will be affected by terrain, air temperature, number of tortoises encountered, etc. Each field group will use their own method to communicate between transect and telemetry crews so that telemetry crews monitor until all transects have been completed for the day. In general, at the end of the day, when each crew has finished their transect and is back at the truck, they make contact with the logistics coordinator for the group. After this coordinator has heard from everyone that day, the telemetry crew is notified. Telemetry crews cease monitoring once they hear from the logistics coordinator or it is 4pm, whichever comes first.
7. DATA COLLECTION AND VERIFICATION

The software you will use for data collection is called Pendragon Forms (Forms 5.1). It has been installed and backed up on every Juno. A great deal of effort goes into creating a monitoring database that is a balance between user friendliness and functionality. Our less constrained approach means that you can enter non-valid data, so extra care and precision are required on your part to ensure the highest quality data comes in from the field.

The goals of Pendragon Forms and Database training are to provide you with the necessary knowledge and practice so that you accurately enter data, and conversely, if you determine that you have incorrectly entered data, to show you how to correct the mistake. The outline below details the individual objectives and standards, as well as the final metric for which you will be held accountable after completing this training.

Refer to Appendices I and II for collection database dictionaries and field explanations.

**Objective 1:** Proficient understanding of database structure.

Each crew member will know 1) the basic terminology (form, sub-form, record, parent, child) and design of the database and how forms are related as parent and child, 2) what an orphan is, how they are created, and how to avoid and/or fix them, and 3) the purpose and initiation of each form and sub-form

**Objective 2:** Proficiency working with database records.

Each crew member will know how to 1) review and edit an already existing record and 2) delete a record (with emphasis on the orphan problem)
Objective 3: Proficient data entry and understanding of database fields.

Each crew member will know 1) the importance of accurately entering data, 2) how to use the on-screen keyboards to enter data.

Objective 4: Proficient understanding of how to use the Built-in GPS.

Each crew member will know how to 1) take a GPS grab, and 2) check the GPS grab for validity

Metrics: Trainees will be expected to maintain their equipment, successfully perform GPS grabs, and accurately record data in their Juno. This will be evaluated based upon successful delivery of complete and valid training line and pre-season LSTS transect data. These demonstrated skills are required by the USFWS in order to participate in monitoring.

Objective 5: Limit and correct data entry errors on electronic and paper forms

Each field technician will 1) understand data required under every data field; 2) enter paper and electronic data in parallel; 3) use these data forms in tandem to check for completion and correctness at data entry, at transect completion, and when reviewing data from other teams.

Metrics: Trainees will submit data in clean, correct, complete, and legible paper format, matching the associated electronic data which should also be error-free. There will be opportunities on training lines, practice transects, and during telemetry practice to demonstrate proficiency.
Objective 1: Understanding of Database Structure

1. Basic Terminology and Design of the Pendragon Database – Databases are complex electronic entities that have whole fields of study devoted to them. Below is a very brief and general review of database information and terminology relevant to your monitoring duties.
   - Database – The Pendragon database you will be adding to while monitoring is comprised of related electronic data that will be organized to allow easy access and querying once finalized. The final database is accumulated in three stages, described in the diagram above and the steps below. Each stage passes through several iterations of Quality Assurance/Quality Control (QA/QC) to create an accurate database.
     i. While you and your crewmate are in the field collecting data on your Juno
     ii. When the Junos for each field team are sync’d to the computer every few days so your data are merged with that of other crews and with data collected previously by your group
     iii. When data from all field teams are merged at the end of the monitoring season into one complete database.
   - Form – Within the Pendragon database on the Juno, a form is an electronic sheet of monitoring questions to be answered by you. Questions within each form relate to one subject and each form is detailed in Standard 3 of this objective. Forms are the
building blocks for the database – each time you complete a form, it will become a record in a table within the final database.

- **Sub-form (Parent and Child)** – A sub-form is a form that can only be accessed through and is dependent on another form. Another term for this is a Parent and Child relationship. For example, the Transects form is the access point for several other forms. Transects is a Parent form and is the only Parent form for the transects database. The Child forms are the Waypoints, OppLiveObs, OppCarcObs, TranLiveObs, and TranCarcObs forms. A Child form cannot exist until a Parent form is created. This is called a one-to-many relationship; a single transect can have many observations or waypoints, but an individual waypoint or observation can belong to one and only one transect. The figure below diagrams the Parent and Child structure of our transect database.

![Diagram of Pendragon Forms Monitoring Database](image)

- **Record** – A record is a single event within a database table. Each individual transect, waypoint, live or carcass transect tortoise, and live or carcass opportunistic tortoise is a record. Records are related to records in other tables via a primary key, also known as a unique identifier. A transect’s primary key is carried over and recorded in each child form as a means to identify which transect a waypoint or observation belongs to. This primary key is fundamental to creating parent-child relationships, so it also comes into play in the creation of orphan records (Standard 2 of this objective, below).

2. **Orphan Records** – Diagnosing and correcting orphan records when they occur can be a daunting task for the QAQC I manager, but you, the data collector, can make everyone’s job easier by understanding what orphan records are, how they are created, and how to avoid and/or fix them.

- **Orphan Record** – An orphan record is a child record whose parent record has been deleted, hence it is an “orphan”. Our database’s integrity depends on the relationship between the parent form (transects) and the child form(s). That relationship is upheld via the transect form’s primary key. When you begin a new transect form, the primary
key is automatically generated and propagated to each child record created for that transect, establishing the relationship. Without the transect primary key in the child form, there is no link between parent and child. The transect primary key is a hidden field in both the parent and child forms because it is not something you will need to know or edit, but it is important that you understand its role.

- Causes of Orphan Records – An orphan record is created when a child record’s parent record is deleted. For example, you begin a new transect form and initialize the waypoints form. You collect three waypoints before realizing you are walking the incorrect transect and need to start over one kilometer to the west. You delete the transect from Pendragon forms and when you go to delete the waypoints, they are gone, too. Problem solved? Not quite. The waypoints are still there, but there is no way to access them because their parent has been deleted. There is also no way for you to regenerate the parent form and recreate the relationship because the hidden primary key is automatically generated and un-editable. Once the parent form has been deleted, there is no going back; children will become orphans, and your QAQC I manager will have to fix them. The graphic below shows how orphan records are created and how they can be avoided.

- Avoiding Orphan Records – Orphan records are easy to create, but also easy to avoid. If you find that you need to delete a transect record for any reason, start by deleting all child records. After all children have been deleted, the parent can be deleted without creating orphans. How to delete a record is detailed in Objective 2 (database records), Standard 3 of this module.
• Inadvertent deletion of a parent form – Keep in mind that if you are nearing the end of your transect and somehow accidentally delete the transect form, all the child records you’ve collected are still there, just inaccessible. Start a new transect form, giving it the same transect number, resume where you left off, and leave detailed notes about the problem to help your data specialist resolve the issue. There is no need to reenter the child form records. When your Juno is sync’d, those records will show up in the database as orphan records and your data specialist will re-link them with the new transect record you created.

3. **Initiation and Purpose of Pendragon Forms** – There are three Parent forms (Transects, G0_Start, Train_Tran) and seven Child forms (Waypoints, OppCarcObs, OppLiveObs, TranCarcObs, TranLiveObs, G0_Obs, and Train_Obs) that you will use while monitoring. The following outlines some basic information on each form in the transects database and provides a practical guide on how and when to access them on your Juno. Refer to the data dictionary for a detailed explanation of the purpose of each field in a form. Within the parent Transect form, child forms are ordered according to how often you will access and fill them out, so the waypoints form is first.

• Forms 5.1 – To initiate any of the forms, including the Transects form, you must start the Pendragon Forms 5.1 software. With your Juno turned on and on the home-screen, press Forms 5.1 (highlighted below left) and the Parent table options will appear.

• Transects Parent Form -
  i. Purpose - this is the parent form for the transect database and the child forms cannot be accessed until this form is initiated. Its purpose is to record general information about the transect, including names of the observers and condition of the transect (i.e. mountainous, around prohibited access, etc.). The transect record is created when crew members start hiking to the transect (“drop off” point) in the morning, and is closed when crew members return to their drop off point.
  ii. Initiation - when you arrive at your drop off location, initiate this form by selecting Transects and then pressing New (see above right). Only a few of the fields are required before moving to the child forms or ending the transect form, so double check that you have correctly completed everything.
• Waypoints Child Form -
  i. Purpose - while walking a transect, you will create a new waypoint record and take a GPS grab approximately every 500 meters, making this your most frequently completed child form. Waypoints show where you actually walked, so we do not rely on the idealized transect outline or on your descriptions. Every attempted transect must have at least 4 waypoints – waypoint 0 for the drop off location, 1 for the start point, 99 for the end point, and 100 for the return to drop off point. Note that the recorded time for waypoint 0 is the time that you started walking towards your transect and that waypoint 100 is the time you return to the drop off point, NOT the time that you are picked up. These times are used for estimating travel time to and from transect start points.
  ii. Initiation – After you have completed most of the information in the Transects form, the Child Form tables will become visible. To access the Waypoints table and collect a point, press on the Waypoints button, which will take you into the Waypoints record screen, and from there press Add. Fill in the requested information and press Next when necessary, or Previous to go back and review data. When all information is completely recorded, press Next or End until you are returned to the Waypoint record screen. Press Done to return to the Transect form.

• TranCarcObs Child Form –
  i. Purpose – unfortunately, you will find more carcasses than live tortoises, so this child form is next in line. You must fill out a new carcass observation form for every carcass you find while completing a transect. General information about the carcass, such as size, sex, and condition, is requested, along with a GPS grab and basic distance information fields.
  ii. Initiation - to access the TranCarcObs table and record a carcass observation, Press on the TranCarcObs button, which will take you into the Carcass record screen, and from there press Add. Fill in the requested information then press Next, or Previous to go back and review data. When all information is recorded, press Next or End until you return to the TranCarcObs record screen. Press Done to return to the Transect form.
TranLiveObs Child Form –
  i. Purpose – On those happy occasions when you find a live tortoise while walking a transect, this is the form you will complete. Similar to the carcass form, this one requests information on the individual tortoise’s size, sex, location, azimuth and bearing along with a GPS grab and additional tortoise-related data.
  ii. Initiation - to access the TranLiveObs table and record a live observation, Press on the TranLiveObs button, which will take you into the Live record screen, and from there press Add. Fill in the requested information and press Next when necessary, or Previous if you need to go back and review data. When all information is completely recorded, press Next or End until you are returned to the TranLiveObs record screen. Press Done to return to the Transect form.

OppCarcObs Child Form –
  i. Purpose – opportunistic carcasses are tortoise carcasses that are found while not walking the actual transect. Typically this happens while walking from the drop off point to the transect start point or from the end point to the return to drop off point. Requested information is similar to that on the transect carcass child form, but does not include azimuth and bearing because it was not located using the monitoring search method.
ii. Initiation - to access the OppCarcObs table, Press on the OppCarcObs button, which will take you into the Carcass record screen, and from there press Add. Fill in the requested information and press Next when necessary, or Previous if you need to go back and review data. When all information is completely recorded, press Next or End until you return to the OppCarcObs record screen. Press Done to return to the Transect form.

OppLiveObs Child Form -

i. Purpose – this is the least frequently needed child form. Opportunistic tortoises are those found while walking between the drop off point and the transect start or end points, or any other time a live tortoise is found while not walking the transect centerline. Information similar to the transect live child form is requested, with the exception of azimuth and bearing, because these observations are not made using the distance search method.

ii. Initiation – to access the OppLiveObs table, Press on the OppLiveObs button, which will take you into the OppLiveObs record screen, and from there press Add. Fill in the requested information and press Next or Previous to go back and review.

iii. When all information is entered, press Next or End as needed to return to the OppLiveObs record screen. Press Done to return to the Transect form.
The picture below shows a sample transect and when to complete each form.

- **Drop off point** - start Pendragon Forms 5.1 and record preliminary transect data in Transects_08 form. Open Waypoints form and record first Waypoint (0).
- **Start point** - open Waypoints form and record waypoint 1.
- **Waypoint** - open Waypoints form and record new waypoint every 500 meters. The ideal transect has 23 of these.
- **End point** - open Waypoints form and record waypoint 99. Typically near the start point. Signifies end of search strategy.
- **Return to drop off point** - open Waypoints form and record waypoint 100. Typically near the drop off point. Signifies completion of transect.
- **Transect Carcass Tortoise** - open the Transect Carcass form and record carcass data.
- **Transect Live tortoise** - open the Tran Live Observation form and record tortoise data.
- **Opportunistic Live tortoise** - open the Opportunistic Live form and record tortoise data (opportunistic carcass not shown).
Objective 2: Working with Database Records

Every desert tortoise monitoring crew is responsible for delivering their Juno containing accurate data, a goal best achieved by reviewing records twice - immediately after collecting them, and then again after the transect is complete. This objective focuses on how to approach the important task of data review and editing, including deletion.

1. **Review and Edit an Existing Record** – You are able to review and edit a record immediately after collecting it. This reduces the chance of incorrect data because you are not compelled to attempt hours later to correct something that is no longer fresh in your memory. As a further check, you will compare your electronic and paper data after the transect is complete. The steps below outline how to review and edit a record. The steps are essentially the same for every form, so the waypoints form is used for illustration.

   a. Reviewing records while collecting data

      i. While in the process completing a record, you can always press Previous to review what you have already collected and make changes as necessary.

      **NOTE** – It is strongly recommended that as you and your teammate are collecting data, you repeat aloud the information as you either write it down or record it in the Juno. Consider a situation in which your teammate measures a tortoise and deems it to be 200 millimeters, but you hear 300 and record that in the Juno while they record 200 on the paper. At the end of the transect, after 5 hours of walking, neither of you can recall which is correct and are forced to leave the records mismatched. The problem could probably have been avoided by verbally repeating the entries.

      ii. After completing and exiting a record, you will be returned to the sub-form of whatever you were collecting. If you would like to review a record, simply press on it. Or, if you have returned to the Parent transect form, press the child form that you would like to view and press the record in question.
iii. Scroll through the screens by pressing Next. If you need to change anything, press on the field and correct it, just as you would when entering data.

iv. After reviewing and correcting the record, either press Next until you are returned to the sub-form screen or press End. Press Done to return to the Parent Transect form.

b. Reviewing records after a transect is complete

i. To further ensure your data are correct, you will compare your electronic data entries to your paper data entries after completing a transect and before turning in your Juno. It is common for one team member to read off what is on the paper form while the other compares it to the data on the Juno.

ii. When a discrepancy arises between the paper and the Juno, you must attempt to resolve the issue by either correcting the data on the Juno or correcting the paper data sheet, but if you cannot recall which is correct, do not guess and randomly change one answer to match the other. Instead, let the discrepancy remain and leave an electronic comment for your data specialist so they are aware of the issue. This is why double checking entries while in the field is crucial.

iii. To review a transect after completing and closing all forms, start Forms 5.1 on your Juno by pressing on its icon in the application launcher menu.

iv. Make sure the Transects form is selected and instead of pressing New, as you would when starting a new transect, press Review.

v. Any transects that have been completed and have not been transferred to the Sync computer will be listed. Press on the transect you want to review and the Parent Transect form will open with the previously collected data.

vi. From here, follow the steps detailed above to view and edit your entries as necessary.
2. **Delete an Existing Record** - Sometimes you want to delete a record and start over. This is easy to do, but use caution because if you delete a transect record before deleting the waypoints or other child records that have been collected, you will create orphan records (see Objective 1, Standard 2 of this module). Delete any child records before deleting the parent record and your data will be orphan free. You must also take care to avoid deleting a form, which is what you fill out to create the record, instead of the record itself. Make sure you are viewing an actual record before deleting it and are not at the form level (i.e. if the words “Delete Form Designs” show up, do not proceed). The method for deleting a record is the same for every form, but the screens below demonstrate deleting a waypoint. **NOTE** – You may have noticed the Delete button in the lower right hand corner of the Pendragon Forms main screen. This button is not recommended because it deletes an entire transect without giving you the option to delete the child records first, creating orphans. Use this button only if you have not collected any child records or have already deleted all child records.

a. Access a record that you would like to delete by following the review steps above (Standard 1 of this objective) and press to open it.
b. Press in the upper left hand corner of the Juno screen, where the title of the form is (Waypoints_12).

c. This opens the Menu Bar, which allows you to access the edit options for the Sub-form.

d. By default, the drop down Edit menu is available, but you want the Record drop down menu, which will become active if you press on Record.

e. Under the Record menu, press Delete/Cancel.
f. If you are sure you want to delete the record, press Yes, otherwise press No.

If you are deleting an entire transect, delete every waypoint and observation first (child records), then delete the transect record (parent record), otherwise you will create orphans. For more information on orphans, refer to Standard 2, Objective 1 of this module.
Objective 3: Understanding How to Enter Data on Juno

1. Importance of Data Entry – as already stressed, accurate data is extremely important to tortoise monitoring. The accuracy begins with and relies heavily upon you, the monitor. The first and often most important step in achieving accurate data is inputting it correctly. On this project there is one method for hand-entering data: the onscreen keyboard. Use either the default keyboard or press \((=)\) to make numbers easier to enter. Pick whichever method is most comfortable for you, as long as the data you enter are accurate. Timely, but very accurate, data entry is key.

2. On Screen Keyboard - with the cursor in a field where data can be entered, do the following to activate a keyboard:
   
   i. Press \((=)\) at the bottom of the Juno Screen to display the default keyboard, or press \((.)\) for the numeric keyboard.

   ii. Press the desired characters or numbers into the data field. Click on the \(\) button to hide the keyboard. The keyboard is displayed below the Pendragon forms screen so the keyboard can remain visible while entering data.

   iii. Below is what the screen will look like with and without the keyboard; the windows and transect heading will disappear when using the keyboard. Tap the keyboard icon to hide the keyboard, and the headings will reappear.
Objective 4: Using Built-In GPS and JUNO Together

1. **Take a GPS Grab** - Every child form requires that you collect spatial coordinates, i.e. an easting and a northing, which are transferred from the Built-In GPS unit to your Juno. This is often referred to as “taking a grab” and here’s how to do it:
   - To record a point, either a waypoint or a tortoise, make sure the GPS has had a minute to warm up before collecting data.
   - Collect the other requested data as described previously.
   - At the GPS Location screen, tap Acquire. The Juno will now search for the GPS location.
   - The Juno will attempt to connect to and receive a location from the Built-In GPS. Hold the Juno so it is directly over the point you want to record (tortoise, carcass, or waypoint) and has as clear a view of the sky as possible. The GPS location recorded in your Juno will be the location of the Built-In GPS, **NOT** the location of the navigational GPS the other observer is using. In other words, if your crew member has a navigational GPS and is 20ft ahead of you and you are attempting to record the location of a tortoise at your feet, the locations recorded will be different, one where your crew member is and one where you are. Be mindful of this when acquiring data.
     i. Though the GPS field in Pendragon form shows "No Lock. GPRMC ok. GPGGA ok. Error (" but it is trying to connect to the satellites in background. If the coordinates do not transfer to and display on the Juno within roughly 3 minutes, the connection will time out, at which point you should either manually enter the Easting and Northing based on your navigational GPS unit or give it another go. Try getting the coordinates off the Built-In GPS at least two times before resorting to the navigational GPS. There are many reasons for a grab to not work – too few satellites, poor satellite geometry, cloud cover, trees (not a problem for us), etc. If your Built-In GPS consistently does not transfer coordinates, notify your team leader or data specialist to see about a solution.
ii. If the grab works and the coordinates transfer, you will see a screen, which refreshes itself frequently, displaying the coordinates of where the Juno unit thinks it is, along with the HDOP and number of satellites. This screen is important and requires some scrutiny on your part because the HDOP and the number of satellites are indicators of how reliable the grab may be, neither of which are available after you tap Fix.

- HDOP is a complex statistic, but what you need to know is that the higher the HDOP value, the worse the satellite geometry is and the less reliable the grab. An HDOP of 2 is good, while an HDOP of over 6 indicates a questionable grab that should be checked against the navigational GPS. Studies have shown the relationship between HDOP and signal quality is not guaranteed, but lacking other information it is a good educated estimate.

- The number of satellites is a little more straightforward; the more satellites there are, the better the grab is likely to be. A grab that is recorded with fewer than 5 satellites is less reliable and should be compared with the reading on the navigational GPS.

iii. If both HDOP and number of satellites are reasonable, or the Easting and Northing are within 20 meters of the Easting and Northing on the navigational GPS, tap Fix.
iv. After tapping Fix, if for any reason you would like to retake the point, tap Acquire again and repeat the process.

Otherwise, tap Next and continue collecting data. Only if the GPS grab fails do you need to manually enter the Easting and Northing when prompted by the Juno.

2. **Check the GPS grab** - Occasionally the Built-In GPS units will transfer an erroneous coordinate reading to the Juno. Based on past experience, many faulty readings are due to fixing coordinates before the GPS unit has sufficient time to establish contact with available satellites and calculate its exact location. The following guidelines have almost eliminated these errors:

- Every time you collect a point, allow the Built-In GPS at least 20-30 seconds before fixing the location. The majority of your points will be waypoints with a 10 to 20 minute walk between them, which is long enough for the unit to lose its location.
- Error can also be introduced when too few satellites are available or when the geometry of available satellites is poor. To minimize this error, it is important to check that the easting and northing transferred to the Juno by the Built-In GPS are similar to the easting and northing on your navigational GPS. If your Juno’s easting or northing differs more than 20 meters from those of your navigational GPS, try retaking the point. If that does not work, hand-enter the coordinates from your navigational GPS. Compare the Built-In GPS coordinates to the navigational GPS coordinates whenever:
  - Your Juno has been off for more than an hour
  - Your HDOP is greater than six
  - There are fewer than five available satellites
  - There was any indication of a hitch in the grab process (the grab took an unusually long time)
Note that because your Navigational GPS is on continuously throughout the day and is likely of higher manufacture quality than the Juno’s Built-In GPS, we make the assumption that when there is a conflict between the two units the Navigational GPS is correct. We are also making the assumption that you are carrying (e.g. maintaining good sky visibility) and caring for your Navigational GPS correctly.

Objective 5: Limit and Correct Data Entry Errors

1. Crews proof their Juno and paper data sheets for missing entries every day.
   In so doing they should find and complete any blank data fields assuming an answer can be found on the paper data sheet. If they cannot complete a blank data field it should be reported to the QA/QC specialist when data from their Juno are downloaded.

2. Crews compare their Juno and paper data sheets for discrepancies.
   Discrepancies between the two should be resolved immediately. Any discrepancies that you are unable to resolve should be reported to your QA/QC specialist when data are transferred. QA/QC specialists will record these errors in the database so they do not cost recurring effort during future weekly data checks.

3. Crews will be apprised of identified issues so they can correct the way they enter data for future deliveries.
   All resolvable, correctable, or fixable (synonyms used for emphasis!) data entry issues should be resolved before submitting the data to MDEP (performs the next, independent level of QA/QC). With each passing day, issues become more and more difficult to fix.

Note that following proofing by individual crews, the combined records from all crews in each field group are scrutinized carefully each week by QA/QC I and by the U.S. Fish and Wildlife Service. Any issue uncovered in this process will be clarified by the QA/QC specialist, so crews should preemptively explain unusual situations using comment fields to avoid delayed and time-consuming resolution by the specialist.

The QA/QC specialist will follow up with specific crews when weekly checks identify a recurring issue with their team’s data. In addition, crews are responsible for ensuring they have discussed each weekly assessment provided by the U.S. Fish and Wildlife Service to the crew leaders. These assessments report on issues that are priorities for all field crews.

The following graphic is based on last year’s datasheet, but the comments and clarifications about legible and complete forms still apply.
<table>
<thead>
<tr>
<th>Transect Number</th>
<th>Date</th>
<th>Observer 1</th>
<th>Observer 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>340</td>
<td>May 7, 2011</td>
<td>Tess Kreofsky</td>
<td>Erica Berlin</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Waypoint</th>
<th>Time</th>
<th>Easting</th>
<th>Northing</th>
<th>UTM Zone</th>
<th>Original bearing photo taken?</th>
<th>New bearing photo taken?</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5:33</td>
<td>1342000</td>
<td>4013393</td>
<td>12</td>
<td>Y</td>
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<td>Y N</td>
</tr>
<tr>
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<tr>
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<td>4013593</td>
<td>12</td>
<td>Y</td>
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<td>Y N</td>
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<tr>
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<tr>
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</tr>
<tr>
<td>3</td>
<td>6:26</td>
<td>135763</td>
<td>4014509</td>
<td>12</td>
<td>Y</td>
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<td>Y N</td>
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</tbody>
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<table>
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<tr>
<th>Waypoint 8</th>
<th>Time</th>
<th>Easting</th>
<th>Northing</th>
<th>UTM Zone</th>
<th>Original bearing photo taken?</th>
<th>New bearing photo taken?</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y N</td>
<td></td>
<td></td>
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<td>Comments:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data recorded by: Tess Kreofsky
Edited by: Vicki Menchow

Note: All data must be proofed, every page, every time.
**Desert Tortoise Distance Sampling Transect Form (Waypoints 4)**

**Transect Summary**

- **Entered fields:**
  - Transect bearing
  - Partial side length (a)
  - Intersection bearing
  - Planned side length (l)

- **Calculated fields:**
  - 1st dist to walk (l-a)
  - 2nd dist to walk (l-b)
  - 3rd dist to walk (l-b)
  - 4th dist to walk (b)

- **Transact Standard?**
  - Yes [x] No

- **Terrain Obstacles:**
  - Mountainous
  - Cliff
  - Deep Washes
  - Prohibited Access
  - Major Road
  - Boundary

- **Substrate Obstacles:**
  - Rock
  - Gravel
  - Talus
  - Sand

- **Other Obstacles:**

**Other relevant information (military reservation, wilderness area, etc.):**

**Directions to transect (include steep/challenging road conditions, interest major roads, description of notable intersections):**

**Changes in Transect Shape**

Please sketch the transect walked on the diagram to the left, including numbered waypoints and observation locations (T1 = Live Tortoise 1, C1 = Carcass 1).

**Comments:**

Cliff interruption. Cold and rainy hydrographic transect.

**Data recorded by:** Erva Bieren

**Data proofed by:** Kelly Hardin

---

- Always record all waypoints - not just corners - on the transect diagram.
- Draw all transect and opportunistic tortoise and carcass observations so as to indicate where they were seen relative to the transect (between which waypoints, on which side of the line), if applicable.
- Topographic features of interest may be shown on the diagram. If there is an interruption, show or describe what caused the interruption.
- If there is an interruption, show the transect numbers for the different segments on the diagram.

Make sure every page has a page number. Number all the pages from one transect together in one sequence. The official order for the pages is:

1. Waypoints (4-5 pages)
2. TranCarcObs
3. TranLiveObs
4. OppCarcObs
5. OppLiveObs

Always include a Waypoints page 3, even if you do not use it, so that the transect diagram will be on page 4.
APPENDIX I: ANNOTATED PAPER DATA SHEETS
### Desert Tortoise Distance Sampling Training Transect Form

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>Transect Bearing</th>
<th>Group</th>
<th>Team Number</th>
<th>Training Segment Num</th>
<th>Lead</th>
<th>Follow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>35°, 215°</td>
<td>Kiva</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Training line color</th>
<th>Training Date</th>
<th>Start Post</th>
<th>Local Bearing</th>
<th>Observations</th>
<th>Azimuth</th>
<th>Radial Dist</th>
<th>Perpendicular Dist</th>
<th>Tortoise Size</th>
<th>Tortoise ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red Yellow Magenta</td>
<td>2015</td>
<td>A B C D E F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Orange Green</td>
<td></td>
<td>G H I J K L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

- If more than 10 detections occur on a segment, use a new data sheet.

- Copy header information and record stop time on all sheets. Total page count each day.

**Data Recorded By:**

**Data Proofed By:**

---

**Trial number**

It usually takes 2 days to complete a trial (walk 16 transects). The first 2 days walked on training lines is "Trial 1". Likewise, the second pair of days is "Trial 2".

**Date**

To avoid data entry errors, dates are reported as DD MMM YYYY, with months indicated by 3-letter abbreviations. For instance, "20 Mar 2012".

**Start Post**

Each starting post identifies a new "transect" and a new form must be started on paper and in the Juno.

**Transect Segment Num**

This is calculated in the Juno. If the number is incorrect or does not display, recheck your LineColor, StartingPost, and TransectBearing.

**Observation time**

Write the time in the same format (12- or 24-hour) that it appears on the RDA.

**Original observation**

If this particular model was first seen using the distance search technique from the centerline, circle "from line". If the model was seen while working at the previous model, circle "while at another model".

**Radial Distance**

Enter only to one decimal place (tenths of a meter).

**Perpendicular Distance**

The former is entered; the latter is calculated automatically. Consider the resulting "perpendicular distance from the line". Does it match your eyeball estimate? If not, recheck your bearing, azimuth, and radial distance entries.

Partial calculations may appear in the box when only a portion of the necessary data has been entered. Touch the box for Perpendicular Distance to recalculate before writing the value on your paper sheet.

The RDA will not round the Perpendicular distance calculation at all. On the paper sheet you must enter only to one decimal place.

Rules for rounding to one decimal place: if there is a 0, 1, 2, 3, or 4 in the second decimal place, do not change the first decimal place. If there is a 5, 6, 7, 8, or 9 in the second decimal place, round the first decimal place up.

**Data proofed by**

This field should record the name of the first reviewer who was not involved in collecting the data. On monitoring transects, data are proofed by the member of a different team, the crew leader, or QAQC specialist.

On training lines, proofing is done by the QAQC specialist.
### Desert Tortoise Distance Sampling G0 Start and Obs Form

<table>
<thead>
<tr>
<th>Photo 1</th>
<th>Yes</th>
<th>No</th>
<th>Photo 1 comments:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo 2</td>
<td>Yes</td>
<td>No</td>
<td>Photo 2 comments:</td>
</tr>
<tr>
<td>Photo 3</td>
<td>Yes</td>
<td>No</td>
<td>Photo 3 comments:</td>
</tr>
<tr>
<td>Photo 4</td>
<td>Yes</td>
<td>No</td>
<td>Photo 4 comments:</td>
</tr>
</tbody>
</table>

**Tortoise Num:** Burrow  Pallet  Open  Behavior: GPS Location

**Time:**
- Vegetation
- Rock
- Unk

**Easting:**
- Northing:

**URN:**
- Yes
- No

**Moved:**
- Basking
- Mating
- Agonistic
- Digging

**Tortoise location:** Burrow  Pallet  Open  Vegetation  Rock

**Behavior:**
- Unk  AllRest/Active  Moving  Basking  Eating  Mating  Agonistic  Digging

**GPS grab valid?:** Yes  No

---

**Photo 1**

**Photo 1 comments**

The Yes/No field is to indicate whether each of the 4 possible site photos were taken.

Use photos to illustrate the landscape of the site and/or to show burrows used by the tortoises here. Comments provide helpful information to interpret the photo.

**Time**

The first observation of each day at a site determines the "start time" for telemetry observations that day. This time should not be later than the transect start time designated for that day, so telemetry observers must be careful to start early enough to locate their first tortoise by the designated start time.

**Burned?**

This entry is not applicable except in Coyote Springs and Halfway. At these sites, it is important to identify on each occasion whether the tortoise was encountered in a burned or unburned area.

**Tort visible?**

Is the tortoise visible at all? Other fields on the form are directed at describing how visible the tortoise is.

**Dist to burrow (m)**

Without using a tape measure, estimate the distance in meters from this tortoise to the nearest burrow. If in the burrow, the distance is "0". Use "100" if you do not see a burrow within 15m of the tortoise.

**Tortoise location:**

- Burrow
- Pallet
- Open

**Burrow visibility:**

This field must be populated if "Tortoise location = burrow". Consider the burrow as the center of a circle. Visibility will be estimated by the degrees of approach through which the burrow would be openly visible.

- **High**
  - Distinctive characteristics of a burrow (opening, mound, or apron) would be visible from more than 75% of the angles of approach. High visibility includes a burrow out in the open and facing you, or very obvious under sparse vegetation.

- **Medium**
  - The expectation is that most burrows detected on a transect will be “medium” visibility. The approach will be to expect “medium” and then for a given tortoise to decide if use of the other categories is warranted. Medium visibility is defined as more than 25% but less than 75% of the angles of approach. Medium visibility includes a burrow visible under vegetation, but where vegetation obscures tell-tale shapes of the mouth, mound, or apron.

- **Low**
  - The burrow is blocked from view through more than 75% but less than 100% of the angles of approach. Low visibility does not include burrows obscured completely by vegetation.

**Not Visible**

The burrow is completely blocked from view. This will be the case if you plunge into vegetation (usually a shrub) to follow a signal, but nothing is visible from the outside, and the “not visible” tortoise is actually in a “not visible” burrow.
Tortoise-in-burrow-visibility
This field must be populated if "Tortoise location = burrow". Consider the burrow as the center of a circle. Visibility will be estimated by how much of the tortoise can be seen and is related to how deep the tortoise is in the burrow.

High
High visibility tortoises include those at the mouth of the burrow, and easily seen without bending over and no need for use of a mirror or flashlight.

Medium
Medium visibility tortoises include those that require bending over or getting down on your knees and the use of a mirror or flashlight.

Low
Low visibility tortoises include those so deep within a burrow that you are required to lay flat on the ground, searching the depths of the burrow with a mirror or flashlight. Your confirmation of the tortoise may include only an arm or leg, or small portion of the shell.

Not Visible
No part of the tortoise is visible when you look inside with a mirror or flashlight. If the tortoise is in a burrow, and "tort visible? = No", then the burrow and/or the tortoise in the burrow are concealed. If you have indicated that "burrow_visibility = not visible", then the tort_in_burrow_visibility may be high, medium, low, or not visible. However, if the burrow_visibility" is "high", "medium", or "low", then "tort_in_burrow_visibility = not visible".

Tortoise visibility
This field is only used for tortoises not associated with a burrow. Consider the tortoise as the center of a circle. Visibility will be estimated by the degrees of approach through which the tortoise would be openly visible.

Medium
The expectation is that most tortoises detected on a transect will be "medium" visibility. The approach will be to expect "medium" and then for a given tortoise to decide if use of the other categories is warranted. Is it an unusual situation for a transect tortoise? Medium-visibility tortoises are blocked through more than 25% but less than 75% of the angles of approach. Medium visibility includes tortoises slightly obscured by vegetation, including in the open but behind vegetation because of your angle of approach, in a pallet, or under rocks (not in soil or rock burrows).

High
The tortoise would be visible from more than 75% of the angles of approach. Typically, high visibility includes tortoises out in the open, but they could be under vegetation or rocks but not obscured by them, or they could be in a pallet.

Low
The tortoise is blocked from view through more than 75% of the angles of approach. This might be the case if you investigate because it looks like there should be a tortoise there, but it isn’t immediately visible. Low visibility includes tortoises completely obscured by vegetation or rocks, including obscured in a pallet.

Not Visible
The tortoise is completely blocked from view, usually deep in a shrub or high forbs/grasses. Since you will have indicated "Tort visible? = No", this option is redundant, but we maintain it for consistency in the visibility fields.

Behavior
Unknown
The tortoise is not visible, and the behavior cannot be discerned.

AtRestActive
The tortoise is visible, appears to be awake, but does not appear to be doing anything. Compare to "Basking"

Moving
This typically involves the tortoise walking, with the plastron off the ground. However, if you hear what you believe to be the tortoise moving in the back of a burrow, record behavior as moving. Because observers frequently startle the animal, when possible observe behavior before approaching.

Basking
Shell on ground, legs sprawled out to maximum skin exposure posterior or broadside to sun orientation. Compare to "AtRestActive"

Eating
The tortoise appears to be biting vegetation or other possible food items.

Mating
The tortoise is engaged in mating activity with another tortoise (courtship behavior or copulation).

Agonistic
The tortoise is an aggressive interaction with another tortoise.

Digging
The tortoise is modifying a burrow or pallet by digging, or possibly nesting. This can be with all four feet. Sometimes you can discern digging when the tortoise is not visible, (i.e. dirt flying out of the back of a burrow).

If the tortoise is not visible behavior can only be unknown, digging, or moving. Probably 99% of the time it will be unknown.
## Desert Tortoise Distance Sampling Transect Form (Waypoints 1)

<table>
<thead>
<tr>
<th>Waypoint</th>
<th>Time: am / pm</th>
<th>Easting:</th>
<th>UTM Zone: 11 12</th>
<th>GPS grab valid?</th>
<th>Photo to previous waypt?</th>
<th>Photo to next waypt?</th>
<th>Lead (to next): Observer 1 / Observer 2</th>
<th>Photo comment</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

Data recorded by: ____________________________  Data proofed by: ____________________________

Page 3 of
### Transect Form (Waypoints 4)

**Team:**

**Date:**

2015

**Stratum:**

**Transect Num:**

<table>
<thead>
<tr>
<th>Transect Standard?</th>
<th>Y</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unplanned modification?</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Terrain Obstacles:</td>
<td>Mountainous</td>
<td>Cliff</td>
</tr>
<tr>
<td>Substrate Obstacles:</td>
<td>Rock</td>
<td>Gravel</td>
</tr>
<tr>
<td>Other Obstacles?:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other relevant information (military reservation, wilderness area, etc.): 

Directions to transect (include UTM coordinates and/or names of nearest major roads, description of notable intersections, steep/challenging road conditions):

---

### Transect Summary

**Tran num**

The transect number a whole number assigned before arriving at the transect. There is one exception: if an obstacle must be navigated so that there is a break in the transect, the transect number a whole number assigned before arriving at the transect. There is one exception: if an obstacle must be navigated so that there is a break in the transect, record Transect 99 with this electronic record, the last one for the transect.

**Stratum**

This should be written long-hand on the Waypoints transect form. On the continuation pages, the appropriate abbreviation can be used.

**Date**

The RDA reads 4/31/2015. The paper entry should be written 31 Apr 2015. Use and abbreviation instead of numbers for the month.

**Waypoint 0**

The location where the crew left their vehicle. These data are taken when leaving for Waypoint 1, not when you arrive at the site (not the night before...). For interrupted transects, Waypoint 0 is entered only on the base segment, not in the continuation records.

**Waypoint 1**

The start point on the transect. If you arrive at this point early, time should not be recorded until you are about to leave for Waypoint 2.

**Waypoints 2 through 24**

Subsequent waypoints on the transect.

**Waypoints 25 through 40**

These will only be used on non-standard transects, if additional turns or interruptions are made in the transect.

**Waypoint 99**

The final location on the transect. On a standard transect, this would correspond to the return to the original start point, and in sequence would have been "Waypoint 25." For transects that are interrupted and resumed after navigating an obstacle, new electronic records are started, but "99" is used only for the last waypoint on the last segment of the transect.

**Waypoint 100**

Where the crew returns to their vehicle. May differ from Waypoint 0. For interrupted transects, After completing Waypoint 99 for the final segment of an interrupted transect, record Waypoint 100 with this electronic record, the last one for the transect.

**Burrow ct**

While walking from Waypoint 1 to Waypoint 2 (for example), use tick-marks to keep track of the number of burrows you examine for tortoises. Only record burrows that could have held tortoises greater than 180mm MCL, and only if they are not blocked or collapsed. When you arrive at Waypoint 2, while entering relevant data, also enter the count of these tick marks.

**Transect interrupted?**

Are you taking this waypoint as a prelude to navigating around an obstacle (without using the distance searching protocol)? If so, indicate "Y" here so it is understood that the path to the next waypoint was not searched. Once you interrupt a transect, you should continue collecting data on the same paper datasheet, but need to start a new electronic record, using decimal increments to link all parts of the same transect in the correct order.

**Lead**

Indicate the observer who will lead from this waypoint to the next one. You should switch leaders at each corner, so if you are taking the coordinates for waypoint 4 and are at a corner, record the new leader under waypoint 4, not waiting until waypoint 5.
Easting
Northing
On the paper sheet, these fields are recorded from the navigational (handheld) GPS unit. In the Juno, start with a GPS grab. If that fails or is more than 20 meters from the navigational coordinates, use the manual easting and northing fields to record the navigational coordinates. In this case, always record both the easting and the northing.

GPS grab valid?
If the BT differs from the navigational GPS by more than 20m, try regrabbing; otherwise, indicate the grab was invalid and enter the navigational (manual) GPS coordinates. Compare the Bluetooth and navigational GPS units if...
- The Bluetooth has been off for more than an hour
- The HDOP is greater than 5.0
- There are fewer than five available satellites
- There was anything unusual, such as an unusually long grab

UTM Zone
Only entered by hand in the RDA if a manual GPS grab was required

Data recorded by
Data proofed by
The recorder participated in collecting the data. The proofer must be someone other than one of the data collectors. Candidates are other field personnel, crew leaders, or the QAQC specialist.

Transcet standard?
A transect is only “standard” if it was 12km long, with 4-3km sides at right angles to one another. Any other shapes or lengths, or the use of interruptions is

Interrupted tran?
Record whether you have interrupted the transect so that you used more than one electronic transect record to collect the data for this transect.

Unplanned modification?
Record whether you have interrupted the transect so that you used more than one electronic transect record to collect the data for this transect.

Terrain obstacles
Only complete this field if you identified a non-standard transect. What obstacles to forward progress caused you to shorten or otherwise alter your transect

Substrate obstacles
Only complete this field if you identified a non-standard transect. Only substrates that affected ability to complete the transect should be noted here. Loose or

Other obstacles
Only complete this field if you identified a non-standard transect. This field should be used to identify human-built obstacles. “Prohibited access” is a category

Directions to transect
This information is only on the paper sheet, not on the Juno.

Drawing of transect
Draw this free-hand. This is not on the Juno, but provides information that is often referenced during data verification.
**Desert Tortoise Distance Sampling Transect Form (TranCarcObs)**

<table>
<thead>
<tr>
<th>Tran Num:</th>
<th>Team Num:</th>
<th>Date:</th>
<th>Tran Carc #:</th>
<th>Radial Distance:</th>
<th>Other Tag Color:</th>
</tr>
</thead>
<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Observe:</th>
<th>Perpendicular Dist:</th>
<th>Easting:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2</td>
<td>m</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Carcass Condition:</th>
<th>Intact</th>
<th>D/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCL ≥ 180?:</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>MCL (mm):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex:</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>Existing Tag:</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>ET Number:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ET Color:</td>
<td>B</td>
<td>W</td>
</tr>
</tbody>
</table>

**Observer:**
- Lead
- Follow

**Other Tran Bearing:**
- 0°
- 90°
- 180°
- 270°

**Local Bearing:**
- °

**Comments:**

**Opp Carc #**
Remains of a tortoise are recorded as a carcass only if at least half of the shell (plastron and carapace) are present.

**Carcass Condition**
These definitions are project specific. You may have used other definitions, but for us, if the MCL can be measured, the tortoise is "intact," regardless of how much has fallen off or whether carapace and plastron are attached. Otherwise it is "disarticulated."

**MCL ≥ 180?**

MCL (mm)
For all carcasses, the first field will have an entry. The second field will only have an entry if the carcass was intact - this field should not be estimated.

**Sex**
If there is any uncertainty about the sex of the tortoise, record "unknown." Tortoises smaller than 180 mm are generally

**Existing Tag**
For carcasses, the possibilities are that it definitely has an existing tag ("Y"), or that you know it definitely does not have an existing tag ("N"), or the tag exists but is unreadable ("U/R"; ultraviolet can for instance darken tags). Because carcasses can always be removed and examined completely, it will never be appropriate to say it is "unknown" whether the carcass has an existing tag (live tortoises may be "Unk" to have a tag). If you can't find a tag with a carcass now, you won't find one at a later date.

**Existing Tag Color**
- Blue (B)
- White (W)
- Green (G)

**Photo taken**
If you take a photo of the carcass, whether taken as part of this subform or no, indicate "Yes."

Use the photo to capture pictures if you think the carcass is informative, for instance if you think it indicates a particular cause of death. In this case, use the comment field to communicate your intent to the viewer. If the photo was not taken as part of this subform, provide the label assigned by the camera in the comment. Alternatively, if the photo was integrated in the subform, you will not be provided with a photo name and should not fill in the latter field.
Observer Position
It is extremely important to record whether the tortoise was first seen by the person in the "lead" or "follow" position.

Radial Distance
Enter only to one decimal place (tenths of a meter).

Perpendicular Distance
This field is calculated automatically after you enter the 3 input fields and TAP THIS FIELD ON THE JUNO. Does the Juno result match your eyeball estimate? If not, recheck your bearing, azimuth, and radial distance entries. Record result on paper datasheet.

Partial calculations may appear in the box when only a portion of the necessary data have been entered. Touch the box for Perpendicular Distance to recalculate before writing the value on your paper sheet.

The RDA will not round the Perpendicular distance calculation at all. On the paper sheet you must enter only to one decimal place.

Rules for rounding to one decimal place: if there is a 0, 1, 2, 3, or 4 in the second decimal place, do not change the first decimal place. If there is a 5, 6, 7, 8, or 9 in the second decimal place, round the first decimal place up.

Cue to tortoise:
- SearchedVeg - Your attention was captured by a promising shrub, but no part of the tortoise was immediately apparent
- BodyPart - Although the tortoise may not have been completely visible, you identified part of the tortoise and went to investigate
- Burrow - You found the tortoise after going to investigate a burrow. The tortoise might have been in the burrow, or you noticed it in the open after going to investigate the burrow itself.
- BurrowApron - You didn’t see the mouth of the burrow initially, but went to investigate what you thought was excavation from or path into a burrow.
- The tortoise might have been in the burrow or on the apron, or you noticed it in the open after going to investigate the excavation itself.
- Audible - Your attention was captured by a noise (often air being expelled), although when you directed your attention there, the tortoise might also be visible

Tortoise location:
- Burrows include both dirt constructed holes and caliche caves. The plane at the burrow opening shows the boundary of the burrow; at least part of a tortoise in a burrow is inside the boundary. Tortoises in a burrow under a plant are in a “Burrow,” not under “Vegetation”
- Vegetation - tortoise is under the drip line, or if the plant is columnar, it is in the shade of vegetation.
- Rock - tortoise is under or in the shade of a rock.
- Pallet - tortoise is in a similar configuration to the mouth of a burrow, but the shelter is shorter than one tortoise length.
- Open - tortoise is in the open and not under vegetation or rock.

Tort heading relative to line when detected:
This question is about the orientation of the tortoise when you first saw it. Indicate all applicable descriptions.
- Profile - The tortoise was in a burrow and neither head-in or head-out, or was out of a burrow and approximately perpendicular to the transect line
- TailOn - The tortoise is not in a burrow and is facing away from the transect path
- PulledIntoShell - The tortoise's legs and head were retracted
- FacingIntoBurrow - at least part of the tortoise is inside the mouth of a burrow, and the animal is facing into the burrow
- FacingOutOfBurrow - At least part of the tortoise is inside the opening of the burrow, and the tortoise is facing out from the burrow.
Burrow visibility:
Consider the burrow as the center of a circle. Visibility will be estimated by the degrees of approach through which the burrow would be openly visible.

Medium
The expectation is that most burrows detected on a transect will be “medium” visibility. The approach will be to expect “medium” and then for a given tortoise to decide if use of the other categories is warranted in case this is an unusual situation for a burrow. Medium-visibility burrows are not visible through more than 25% but less than 75% of the angles of approach. Medium visibility includes a burrow visible under vegetation, but where vegetation obscures tell-tale shapes of the mouth or apron.

High
Distinguishing characteristics of a burrow would be visible from more than 75% of the angles of approach. High visibility includes a burrow out in the open and facing you, or very obvious under sparse vegetation.

Low
The burrow is blocked from view through more than 75% of the angles of approach. This might be the case if you investigate because it looks like there should be a burrow there, but it isn’t immediately visible. Low visibility includes burrows obscured completely or nearly completely by vegetation.

Tortoise-in-burrow-visibility

High
High visibility tortoises include those at the mouth of the burrow, and easily seen without bending over and no need for use of a mirror or flashlight.

Medium
Medium visibility tortoises include those that require bending over or getting down on your knees and the use of a mirror or flashlight.

Low
Low visibility tortoises include those so deep within a burrow that you are required to lay flat on the ground, searching the depths of the burrow with a mirror or flashlight. Your confirmation of the tortoise may include only an arm or leg, or small portion of the shell.

Tortoise visibility
This field is only used for tortoises not associated with a burrow or caliche cave. Consider the tortoise as the center of a circle. Visibility will be estimated by the degrees of approach through which the tortoise would be openly visible.

Medium

The expectation is that most tortoises detected on a transect will be “medium” visibility. The approach will be to expect “medium” and then for a given tortoise to decide if use of the other categories is warranted. Is it an unusual situation for a transect tortoise? Medium-visibility tortoises are blocked through more than 25% but less than 75% of the angles of approach. Medium visibility includes tortoises slightly obscured by vegetation, including in the open but behind vegetation because of your angle of approach, in a pallet, or under rocks (not burrows or caves).

High
The tortoise would be visible from more than 75% of the angles of approach. Typically, high visibility includes tortoises out in the open, but they could be under vegetation or rocks but not obscured by them, or they could be in a pallet.

Low
The tortoise is blocked from view through more than 75% of the angles of approach. This might be the case if you investigate because it looks like there should be a tortoise there, but it isn’t immediately visible. Low visibility includes tortoises completely obscured by vegetation or rocks, including obscured in a pallet.

Distance to burrow
Without using a tape measure, estimate the distance in meters from this tortoise to the nearest burrow. If in the burrow, the distance is "0". Use "100" if you do not see a burrow within 15m of the tortoise.

MCL≥180?

For all visible tortoises, the first field will have an entry. Although "Unknown" is an option, indicate "Yes" or "No" if at all possible. If the tortoise is the size of a measurable burrow opening, for instance, use this to evaluate whether it is larger than 180mm. The second field will only have an entry if the tortoise was handled - this field should not be estimated.

Sex of tort
If there is any uncertainty about the sex of the tortoise, record "unknown."
It is more difficult to identify the sex of smaller tortoises. In particular, those under 180mm are often considered juveniles.

Body condition score
Please reference the handbook for pictures to illustrate muscle development and fat deposition evidence to match each score.

Nares appearance
If any fields are left blank, even if you are able to conclude the transect form, your QAQC specialist will have to interview you to attempt to fill in information. If you can instead use one of the pick list provided here, or can clearly describe a different situation that prevented handling of the tortoise, then the extra follow-up work will be avoided.

Normal - Usual shape and/or size.
Asymmetrical - One naris is larger and/or wider than the other.
Eroded - Loss of scales and skin around naris opening.
Occluded – Plugged or reduced size of naris opening.

Waypoint 100
Nares discharge

None - No discharge from either naris

Serous - Clear, watery discharge. Must simultaneously score the severity (1, 2, or 3) based on the naris with the most severe level of discharge.

Mucous - Thick discharge, usually cloudy. Must simultaneously score the amount (1, 2, or 3) based on the naris with the most severe level of discharge.

1 - Moisture present around one or both nares.

2 - Discharge coming out of at least one of the nares, but not running far from the nares themselves.

3 - Discharge coming from at least one naris that is running down the beak.

Unknown - If the tortoise’s behavior prevents you from examining the nares, continue processing and collecting data. Attempt to score the nares one more time before leaving the location, but do not manipulate the tortoise to attempt the examination.

Existing Tag

For live tortoises, the possibilities are that the tortoise definitely has an existing tag (you have been able to handle the tortoise, see it in the open, or have a clear view of the tag on the tortoise in a burrow), or that you know the tortoise definitely does not have an existing tag (you have been able to handle the tortoise or see it in the open), or the tag exists but is unreadable ("U/R"; ultraviolet can for instance darken tags), or you can’t see the entire tortoise, cannot handle it, and you can’t confirm that the invisible portions are tag-less.

FW- tag numbers are recorded without hyphens. All other tag numbers are recorded as they appear.

Existing Tag Color

If any tag is present, it is likely to be blue, white, or green. Otherwise, use "Other tag color" and spell it out!

In the Juno, start with a BT GPS grab. If that fails or is more than 20 meters from the navigational coordinates,

- If any fields are left blank, your QAQC specialist will interview you to attempt to fill in information. If you can instead use one of the pick list provided here, or can clearly describe a different situation that prevented handling of the tortoise, then the extra follow-up work will be avoided.
- Deep in burrow - Tortoises should only be extracted from burrows if the animal does not struggle or become agitated
- Scutes too small - This situation would preclude affixing a tag
- Social interaction - Tortoises that are courting, mating, in combat, or other social interactions should not be disturbed
- Research area temperature - Transmitted animals or others under behavioral observation in designated areas should not be approached
- The HDOP is greater than 5.0
- Other - Use this option to describe another situation, or to retract an entry under this field

Photo_tort

Photo comment

If you take a photo of the tortoise, whether taken as part of this subform or no, indicate “Yes.”

Use the photo to capture pictures of cooperative tortoises if desired, or of nares or body condition features to clarify scoring. In the latter cases, use the comment field to communicate your intent to the viewer. If the photo was not taken as part of this subform, provide the label assigned by the Juno in the comment. If the photo instead was integrated in the subform, you will not be provided with a photo name and should not fill in the latter field.
<table>
<thead>
<tr>
<th>Tran Num</th>
<th>Stratum</th>
<th>Team Num</th>
<th>Date</th>
<th>Opp Carc #</th>
<th>Sex</th>
<th>ET Number</th>
<th>MCL &gt; 180?</th>
<th>MCL (mm)</th>
</tr>
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<tbody>
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**Tran Num**

Opportunistic carcasses must be associated with a transect. Once you have closed out your transects (for instance when camping later that day), you may process the tortoise, but will have to reopen the corresponding transect record and add the data to the appropriate paper and electronic forms.

**Opp Carc #**

Remains of a tortoise are recorded as a carcass if at least half of the shell (plastron and carapace) are present. For each transect, restart numbering sequentially from 1.

**Carcass condition**

These definitions are project specific. You may have used other definitions, but for us, if the MCL can be measured, the tortoise is "intact," regardless of how much has fallen off or whether carapace and plastron are attached. Otherwise it is "disarticulated."
Opportunistic tortoises must be associated with a transect. Once you have closed out your transects (for instance when camping later that day), you may process the tortoise, but will have to reopen the corresponding transect record and add the data to the appropriate paper and electronic forms.

For each transect, restart numbering sequentially from 1.