PREPARING FOR ANY ACTION THAT MAY OCCUR WITHIN THE RANGE OF THE MOJAVE DESERT TORTOISE (*Gopherus agassizii*)

The Mojave population of the desert tortoise (*Gopherus agassizii*) was listed by the U.S. Fish and Wildlife Service (USFWS) as threatened on April 2, 1990 (USFWS 1990). Subsequently, proposed actions within the range of the desert tortoise fall under purview of the Endangered Species Act 1973, as amended (ESA), in addition to State regulations. For detailed information on the ecology of the Mojave desert tortoise, please see USFWS (2010).

This protocol provides recommendations for survey methodology to determine presence/absence and abundance of desert tortoises for projects within the range of the species and a standard method for reporting survey results. Information gathered from these procedures will: 1) help determine the appropriate level of consultation with USFWS and the appropriate state agency; 2) help determine the amount of incidental take of desert tortoises resulting from proposed projects as defined by the ESA and appropriate state laws; and 3) help minimize and avoid take.

This guidance includes:

- Site Assessment
- Pre-project Field Survey Protocol for Potential Desert Tortoise Habitats
- USFWS 2010 Desert Tortoise Pre-project Survey Data Sheet

This guidance is subject to revision as new information becomes available. Before initiating the protocols described below, please check with your local USFWS and appropriate state agency office to verify that you are implementing the most up-to-date methods. To ensure quality and reduce the likelihood of nonconcurrence with survey results, we recommend that the names and qualifications of the surveyors be provided to USFWS and appropriate state agency for review prior to initiating surveys.

In Arizona:

U.S. Fish and Wildlife Service
Arizona Ecological Services
323 N. Leroux St., Suite 201
Flagstaff, AZ 86001
(928) 226-0614

In California, for Inyo, Kern, Los Angeles, and San Bernardino Counties:

U.S. Fish and Wildlife Service
Ventura Fish and Wildlife Office
2493 Portola Road, Suite B
Ventura, California 93003
(805) 644-1766

In California, for Imperial and Riverside Counties, and Joshua Tree National Park and the San Bernardino National Forest in San Bernardino Co:

U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
6010 Hidden Valley Road
Carlsbad, California 92009
(760) 431-9440

In Nevada:

U.S. Fish and Wildlife Service
Nevada Fish and Wildlife Office
4701 North Torrey Pines Drive
Las Vegas, Nevada 89130
(702) 515-5230

In Utah:

U.S. Fish and Wildlife Service
Utah Ecological Services Field Office
2369 West Orton Circle
West Valley City, Utah 84119
(801) 975-3330

State Agencies

Arizona Game & Fish Department
State Headquarters--Nongame Branch
5000 W. Carefree Highway
Phoenix, AZ 85086
623-236-7767

California Department of Fish and Game (CDFG)
For Kern County:
Central Region Headquarters Office
1234 E. Shaw Avenue
Fresno, CA 93710
(559) 243-4005 ext. 151

For Imperial, Inyo, Riverside and San Bernardino Counties:
Inland Deserts Regional Office
3602 Inland Empire Boulevard, Suite C-220
Ontario, CA 91764
(909) 484-0167

For Los Angeles County:
South Coast Regional Office
4949 Viewridge Avenue
San Diego, CA 92123
(858) 467-4201

Nevada: Department of Wildlife:
Southern Region
4747 Vegas Dr.
Las Vegas, NV 89108
(702) 486-5127

Utah Division of Wildlife Resources:
Southern Region
1470 N Airport Rd
Cedar City, UT 84720
(435) 865-6100

Site Assessment

Use the key below to assess if desert tortoises may be present within or near the action area and determine survey and consultation requirements. The **action area** is defined by regulation as all areas to be affected directly or indirectly and not merely the immediate area involved in the action (50 CFR §402.02). The extent of the action area is not limited to the "footprint" of the action nor is it limited by the authority of the Federal, state, or local agency or any other entity proposing the project; it can and will vary accordingly with each proposed action. The environmental baseline, the analysis of the effects of the action, and the amount or extent of incidental take are based upon the action area. If you cannot access the entire action area during your surveys for some reason (e.g. access to private property is unavailable), please note that in your survey report.

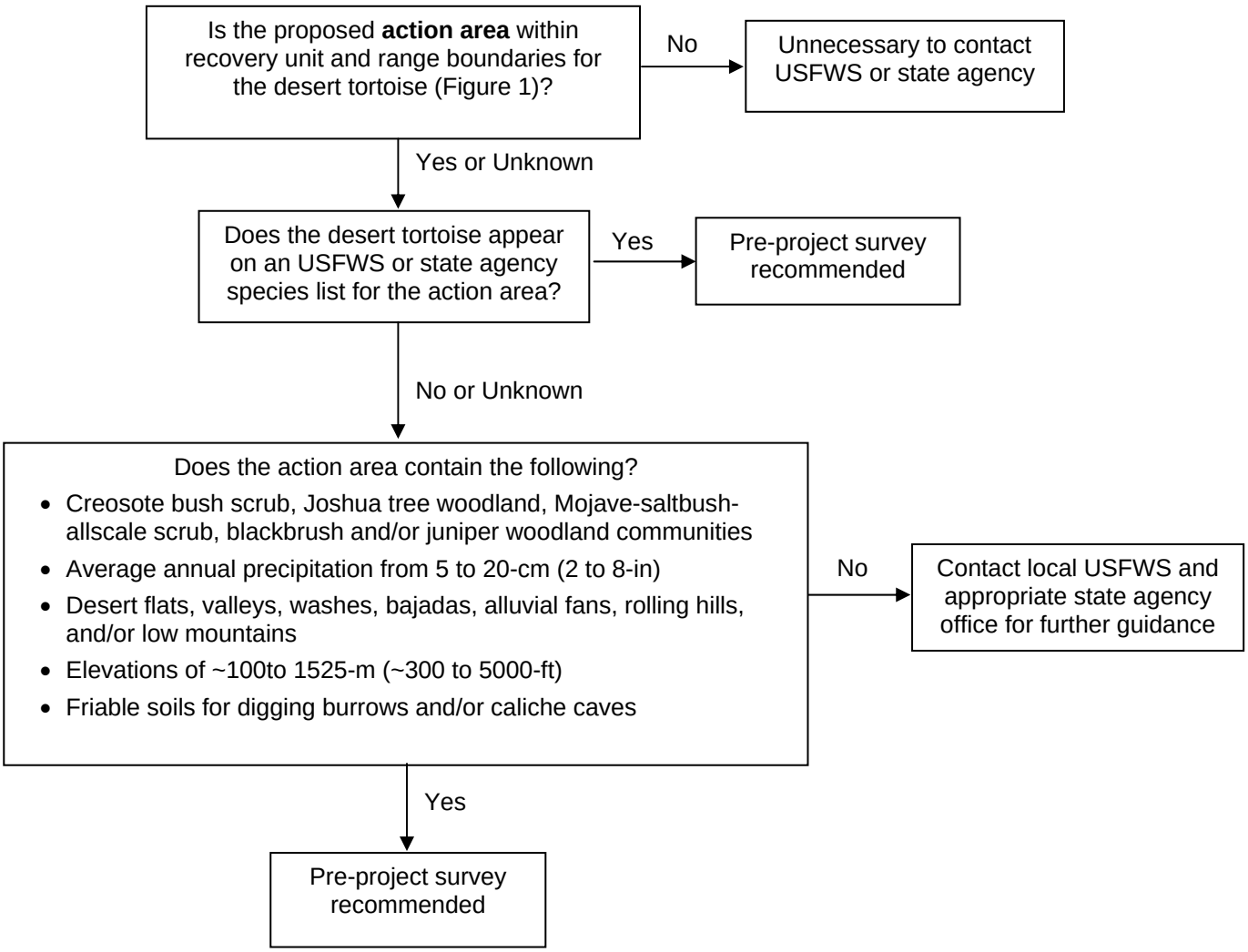


Figure 1. Known range of the desert tortoise (Mojave Population) shown as USGS desert tortoise habitat potential model (Nussear et al. 2009). Boundaries of 2010 revised recovery units are shown, with the North-East Mojave Recovery Unit, split into north and south (as in Table 2).

Pre-project Field Survey Protocol for Potential Desert Tortoise Habitats

Objectives of survey

- Determine presence or absence of desert tortoises within the action area
- Estimate the number of tortoises (abundance) within the action area
- Assess the distribution of tortoises within the action area to inform take avoidance and minimization

See *Frequently Asked Questions* for further definition and discussion of the action area.

Field Methods

This protocol takes into account the fact that not all tortoises within the action area are seen by the surveyor. The following equation accounts for tortoises that are below ground at the time of surveys and for above-ground tortoises that are cryptic and may be missed and should be used to estimate the number of tortoises within the actions area for both 100% coverage and probabilistic sampling.

$$\begin{pmatrix}\text{Estimated number of tortoises}\\ \text{within action area}\end{pmatrix} = \frac{\begin{pmatrix}\text{Number of tortoises}\\ \text{observed above ground}\end{pmatrix}}{\begin{pmatrix}\text{Probability that}\\ \text{a tortoise is}\\ \text{above ground } (P_a)\end{pmatrix}\begin{pmatrix}\text{Probability of}\\ \text{detecting a tortoise,}\\ \text{if above ground } (P_d)\end{pmatrix}}\begin{pmatrix}\frac{\text{Size of action area}}{\text{Size of area surveyed}}\end{pmatrix}$$

- Information to determine presence/absence *and* estimate number of tortoises within the action area is collected during the same survey effort. Surveyed objects include all tortoises that are above ground (both out of burrows and within burrows but still visible), as well as all tortoise sign (burrows, scats, carcasses, etc). Record all locations of tortoises and sign using the USFWS 2010 Desert Tortoise Pre-Project Survey Data Sheet (attached). Please submit a copy of the original datasheets with results of the survey to the local USFWS office within 30 days of survey completion.
- If the action area is large (e.g., 16 hectares [40 acres]) or the project could affect more than 2 or 3 tortoises, surveys should be conducted during the tortoise's most active periods [April through May or September through October when air temperatures are below 40°C (104°F)] (Zimmerman et al. 1994; Frielich et al. 2000; Walde et al. 2003; Nussear and Tracy 2007; Inman 2008). Air temperature is measured ~5-cm from the soil surface in an area of full sun, but in the shade of the observer. Surveys outside these periods may be approved by the local USFWS office when only presence/absence needs to be determined.
- Ten-meter (~30-ft) wide belt transects should be used during surveys. For all projects, surveys which cover the entire project area with the 10-m belt transects (100% coverage) are always an acceptable option. For very large action areas, probabilistic sampling may also be an option, such that the appropriate proportion of the action area is surveyed (Table 2). If probabilistic sampling is an option for the project site, each transect should be chosen either systematically or randomly ensuring that the entire action area has an equal probability of being included in the sample. Transects should be completed in a random order, oriented in a logistically convenient pattern (e.g., lines, squares, or triangles). Any sampling design other than simple systematic or random sampling (e.g. stratification) must be approved by USFWS and appropriate state agency. See *Frequently Asked Questions* for further discussion of 100% coverage and probabilistic sampling.
- USFWS considers the results of a pre-project survey to be valid for no more than one year. If survey results are older than one year, please contact the local USFWS office.

Presence or absence of desert tortoises within the project vicinity

- Occurrence of *either* live tortoises or tortoise sign (burrows, scats, and carcasses) in the action area indicates desert tortoise presence. If either live tortoises or tortoise sign are observed in the action area, contact the USFWS to determine the best manner in which to comply with the Federal Endangered Species Act.
- If neither tortoises nor sign are encountered during the action area surveys and the project, or any portion of project, is ≤ 0.8 k^{m2} (200 acres) or linear, three additional 10-m (~30-ft) belt transects at 200-m (~655-ft) intervals parallel to and/or encircling the project area perimeter (200-m, 400-m, and 600-m from the perimeter of the project site) should be surveyed. These transects are only for the presence/absence determination; they are not included in the estimation of tortoise abundance. See *Frequently Asked Questions* for an explanation of why additional surveys are needed.
- If neither tortoises nor sign are encountered during the action area surveys, as well as project perimeter surveys where appropriate, please contact your local USFWS office. This will allow the USFWS to advise you on how best to demonstrate compliance with the Endangered Species Act. Also contact the responsible state agency to determine compliance with State laws.

Number of tortoises within the action area

The attached Table 3 spreadsheet will estimate the number of adult tortoises (>160 mm MCL) within the action area using the "Numbe**r** of tortoises within the action area" equation from above.

Enter the requested information into the Table 3 spreadsheet, as follows:

1. Enter the area of the total project.
2. Enter the appropriate value from Table 1 for the term "probability that a tortoise is above ground" (P_a).
3. Enter the number of adult tortoises (>160-mm midline carapace length) found during the survey of the action area for the term "number of tortoises observed above ground" (n).

Table 1. Probability that a desert tortoise is above ground (P_a) relative to the previous winter's rainfall (October through March)

Use amount of rainfall from the winter preceding the pre-project survey to determine which value of P_a *is appropriate for the project*

To find this amount of rainfall, go to the Western Regional Climate Center site: http://www.wrcc.dri.edu/summary/Climsmsca.html; click on your location and scroll down to "monthly totals"

Previous Winter Rain	Probability (P_a)	Variance(P_a)
<40 mm (~1.5 inches)	0.64	0.08
≥40 mm (~1.5 inches)	0.80	0.05

The estimate for the term "probability of detecting a tortoise if above ground (P_d)" is already included in spreadsheet Table 3 (P_d = 0.63; variance = 0.011). See *Frequently Asked Questions* section below for how P_a and P_d and their associated variances were estimated.

See *Appendix 1* for a detailed description of the method used to estimate desert tortoise abundance.

100% Coverage or Probabilistic Sampling?

100% coverage surveys are always an acceptable option, regardless of the size of the action area. For very large action areas, probabilistic sampling may be an additional option, such that the appropriate proportion of the action area is surveyed as detailed below. Use the boundaries in Figure 1 and numbers provided in Table 2 to determine if probabilistic sampling could be an appropriate option for the proposed action area.

For the 2010 field season, probabilistic sampling may not be an option for desert tortoise pre-project surveys in California due to the requirement of CESA to avoid, minimize, and fully mitigate (CDFG code section 2081). Please contact your local CDFG office (see contact info on page 2).

Table 2. Is probabilistic sampling an appropriate option for the proposed action area?

Is your action area smaller than the area given below for the recovery unit in which the project occurs?

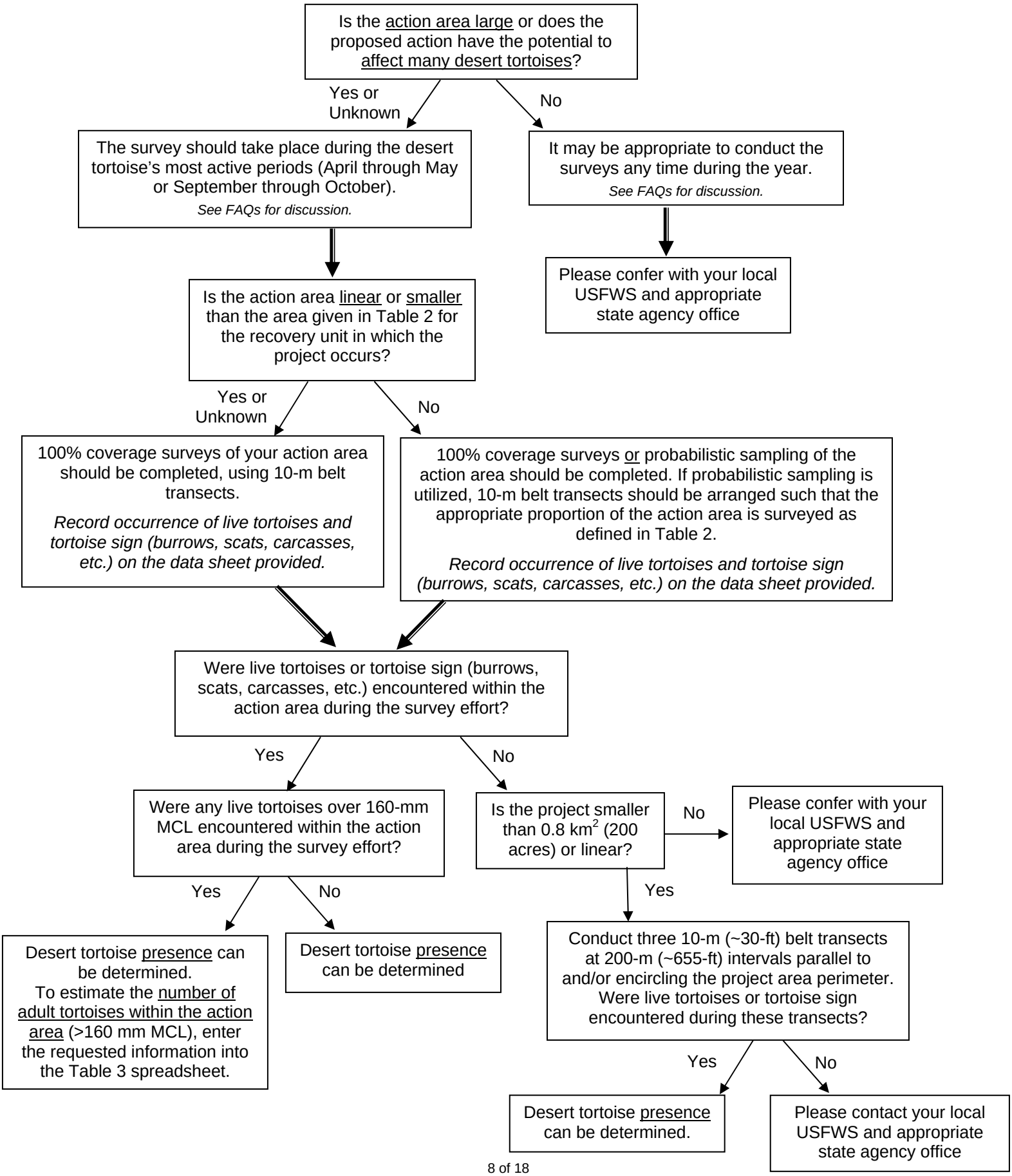
Recovery Unit	Threshold Action Area to Allow Sampling
Western Mojave	4.3 km^2 (1,066 acres)
Colorado Desert	3.3 km^2 (811 acres)
North-East Mojave: North	11.3 km^2 (2,789 acres)
North-East Mojave: South	4.5 km^2 (1,103 acres)
Upper Virgin River	1.1 km^2 (270 acres)

If yes: 100% coverage surveys of your action area must be completed.

If no, total transect lengths that must be surveyed are given below. 100% coverage surveys are also an option, regardless of the size of the project.

Recovery Unit	Total Transect Length (km) to Sample
Western Mojave	431
Colorado Desert	328
North-East Mojave: North	1,129
North-East Mojave: South	446
Upper Virgin River	109

DECISION TREE FOR PRE-PROJECT FIELD SURVEY PROTOCOL FOR POTENTIAL DESERT TORTOISE HABITATS



FREQUENTLY ASKED QUESTIONS: DESERT TORTOISE PRE-PROJECT FIELD SURVEY PROTOCOL

Why did USFWS revise the 1992 USFWS Desert Tortoise Pre-project Survey Protocol?

The 2010 protocol uses the best available science on the desert tortoise to determine presence and abundance. Desert tortoises occur at low densities across most of the Mojave Desert (USFWS 2006). They are cryptic and spend much of their time underground in burrows (Burge 1977; Nagy and Medica 1986; Bulova 1994) and therefore not all animals within an area will be seen by even the best trained surveyors. Tortoises underground in burrows, as well as individuals hidden above ground, need to be included in estimates of abundance.

The 1992 USFWS Desert Tortoise Pre-project Survey protocol was based on a Bureau of Land Management protocol from the mid-1970s, which utilized the best available information at the time, but did not take into account that some tortoises will be underground and missed during the survey effort. The data collected during the USFWS range-wide monitoring program (currently >7,000-km of transects each year; USFWS 2006) have allowed us to improve pre-project survey methods for estimating abundance. Data about the proportion of tortoises underground in burrows, as well as the probability that an above-ground tortoise greater than 160 mm MCL will be observed by the surveyor are included in the estimate of the number of tortoises within the action area (P_a and P_d).

This revised protocol also addresses the potential for using probabilistic sampling when the action area is larger than size limits given in Table 2. 100% coverage surveys are *always* an acceptable option, regardless of size of the action area. For very large action areas, sampling may be an additional option, such that the abundance estimate can be calculated when an appropriate proportion of the action area is surveyed. Estimates of tortoise densities within recovery units have been used to calculate how many km^2 of a project site must be surveyed to produce a statistically robust abundance estimate (Table 2).

Why did you make the change to recommend that the "action area" should be surveyed, as opposed to the "project area? How do I determine the action area?

We recommend that the action area be surveyed to better reflect the scope of an action that USFWS is required to review under the authorities of the Endangered Species Act. When USFWS is considering whether desert tortoises may be affected by a proposed action, we cannot limit our evaluation to the actual footprint of the proposed action; we have to consider all areas that may be affected directly or indirectly by the action. We call this the "action area," which is defined by the implementing regulations for section 7(a)(2) of the Endangered Species Act (50 *Code of Federal Regulations* 402.02), as "areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." (Non-federal actions for which a project proponent has requested an incidental take permit under the authority of section 10(a)(1)(B) of the Endangered Species Act also require consideration of the effects within the action area.)

You can determine the action area by thinking about all components of the proposed action plus desert tortoise ecology, and then calculating the area that may be affected. For example, the proposed action is a 10-acre mine site located adjacent to I-15. From the Harvard Road exit, haul trucks would pull immediately into the mine site. The action area in this case would be the 10-acre mine site. We would not include I-15 in the action area because traffic associated with the mine would not measurably change traffic volume on the freeway.

If the mine operator proposes to conduct blasting activities at the site, the action area includes areas to be affected directly or indirectly by the blasting. If debris moved by the blast, noise, or vibrations would extend beyond the boundaries of the mine site, the area affected by the blasting would become part of the action area. In this case, the delineation of the action area is less than precise; we suggest that you discuss the issue with the project proponent to assess the area that may be affected by the blasting.

As a third example, if the mine site is located 5 miles from Interstate 15 and is accessed by a lightly travelled unpaved road, this unpaved road between the freeway and the mine is part of the action area. We suggest that the access road be treated as a linear project. The road bed itself would not need to be surveyed unless it is so degraded that tortoises would possibly use it for burrowing or shelter; otherwise, place the first transect so that it extends from the edge of the road into the desert, with the second and third transects placed as described in the decision tree. If a new road needs to be built, we recommend that the guidance for a linear project be followed.

If the action area encompasses restricted access private lands, survey the areas for which access is available and note the inaccessible areas in the report. If anything about habitat conditions on the inaccessible areas can be determined (e.g., they support the same type of habitat, are more or less disturbed, etc.), also note that in the report.

What happened to the zone of influence transects recommended in the 1992 protocol?

This revised protocol requires that the entire action area, rather than just the project footprint, be included in the survey effort. The action area provides a more realistic view of where desert tortoises may be affected by the proposed action.

Why is it important to survey during the active period when the action area is large or the proposed action has the potential to affect more than 2 or 3 desert tortoises?

In these cases, USFWS needs more information than just presence/absence to conduct our analyses and determine the extent of the effects on the desert tortoise; we also need a robust estimate of the number of tortoises within the project area, particularly for large projects that involve translocating tortoises >5 km or <5 km. The most expedient way to estimate abundance for tortoises is to conduct surveys when tortoises are most active, when the estimates of the number of tortoises below ground and of the number of tortoises missed during the survey are applicable. As mentioned above, these calculations have been developed from analyses of years of survey data. Abundance estimates will also be useful to the project proponent and lead agencies because it would allow them to conduct their own analyses and assess potential costs of proceeding with the proposed action in this location. The ESA's implementing regulations 50CFR 402 require federal agencies to use the best scientific information which can be obtained during the consultation process, and USFWS to specify the amount or extent of incidental take. Therefore, we have developed this estimate of abundance to comply with these regulations.

What factors does the Service take into consideration when reviewing the results of surveys that are conducted outside the active period?

Surveys outside the active period may be appropriate when only presence/absence is necessary or when the project area is small and only very few tortoises are likely present. We base our determination of whether the results are valid on a whole suite of factors, including but not limited to the type and condition of habitat, the general location of the survey area, the experience of the surveyors, the time and weather when the survey was conducted, the nature of the year in which the survey occurred (i.e., if it rained a lot, desert tortoises are likely to have been active and are more likely to have left evidence of their presence), how much time surveyors spent at the site, and whether they were conducting a focused survey for tortoises or looking for a suite of biological and/or cultural resources. We consider these factors in combination to determine whether the surveyors were likely to have found whatever evidence that desert tortoises were present. Depending on the factors that are present during a survey, the results are more or less likely to represent the true status of the tortoise in that specific area.

What if the pre-project survey was negative (i.e., no desert tortoises or sign) and then a desert tortoise or sign is detected during implementation of the proposed project?

If a tortoise or tortoise sign (shells, bones, scutes, limbs, burrows, pallets, scats, egg shell fragments, tracks, courtship rings, drinking sites, mineral licks, etc.) is found in the action area during implementation of the proposed project, we recommend that all activities that could result in the take of a desert tortoise cease *immediately* and that the USFWS and responsible State agency be contacted. USFWS would need to determine the necessary actions to comply with the ESA; the responsible State agencies would also need to review the situation to ensure their laws are not violated. Please notify the USFWS and appropriate state agency as soon as possible as well as in writing within three days of the discovery. If we determine that desert tortoises are indeed present on site, we would have very limited options for allowing the proposed action to proceed in short order. Consequently, we stress the importance of following USFWS guidance and ensuring that qualified workers conduct the surveys.

How did USFWS determine the values for the "probability that a tortoise is above ground"?

The USFWS range-wide monitoring program estimated the proportion of the desert tortoise population that is visible using telemetered animals from focal areas in spring 2001-2005 (USFWS 2006). This probability is related to the previous winter's rainfall, as illustrated in Table 1. The range of fall above-ground activity is similar to spring numbers, but the variability is much higher (Nussear and Tracy 2007; Inman 2008). Until more robust estimates of fall above-ground activity are available, spring estimates based on the previous winter's rainfall (October through March) are used for surveys conducted in either active period.

How did USFWS establish the value for the "probability of detecting a tortoise, if above ground"?

For the past 5 years, surveyors in the USFWS range-wide monitoring program have undergone training on established transects with artificial tortoises. Trained surveyors detected an average of ~63% of model tortoises that were within 5 m of either side of the transect center-line (USFWS unpublished).

Why are only tortoises over 160-mm MCL used to estimate the number of tortoises within the action area?

The values of P_a and P_d used in the equation to estimate the number of tortoises within the action area are based on USFWS range-wide monitoring data collected for adult tortoises ≥160-mm MCL. Live tortoises of all sizes and tortoise sign are used to determine if tortoises are present within the action are.

What is the purpose of 100% coverage surveys versus probabilistic sampling?

The purpose of surveying is to determine presence/absence and estimate the abundance of desert tortoises within the action area. For 100% coverage surveys, transects are placed across the entire action area; thus, the entire area for which abundance is estimated is surveyed. A probabilistic sampling approach, on the other hand, uses data from randomly or systematically placed transects to draw inferences about locations where surveys are not conducted. All locations for which abundance will be estimated *must* have an equal probability of being included in the sample.

How were the threshold project sizes calculated for determining whether 100% coverage or probabilistic sampling is appropriate?

The validity of probabilistic sampling requires that all locations for which abundance will be estimated have an equal probability of being included in the sample, as well as a minimum expected sample size. Estimating the number of tortoises within the project area using probabilistic sampling is limited by number of tortoises encountered during the survey effort. Therefore, whether or not the project area must be surveyed using 100% coverage or can be probabilistically sampled is based on the area expected to yield a survey count of 20 tortoises (Krzysik 2002). Table 2 uses tortoise densities and detection probabilities estimated from 2004-2009 range-wide line-distance sampling efforts for each tortoise recovery unit (USFWS unpublished) to calculate that area of a project site that must be surveyed to produce a statistically robust estimate. If the project area is large enough to potentially allow probabilistic sampling, Table 2 provides the minimum transect kilometers (10-m wide) that must be surveyed.

What if the minimum length of 10-m wide transect kilometers are completed but 20 tortoises were not found in the action area?

If probabilistic sampling is used and <20 tortoises are found after surveying the total area prescribed by Table 2, the number of tortoises within the action area may be estimated using the number found.

Do I keep surveying if 20 tortoises are found before the minimum transect kilometers that must be surveyed are completed?

If probabilistic sampling was used and the transects have been completed in a random order, project-area surveys may be considered complete when 20 tortoises have been found or the specified number of kilometers have been sampled, whichever happens first. It is okay (even desirable) if more that 20 tortoises are found; this will decrease the width of the confidence interval for the abundance estimate.

Why do small and linear projects where no tortoises were found have to do additional surveys at 200-m (~655-ft) intervals parallel to the project area perimeter?

Even though neither tortoises nor tortoise sign were found within the action area at the time of the survey, the area may be part of an animal's home range. The annual home range of a female desert tortoise averages around 0.15 to 0.16 km^2 (35 to 40 acres), about one third the size of male home ranges, which are variable and can be >2 km^2 (500 acres; O'Conner et al. 1994; Duda et al. 1999; Harless et al. 2009). Therefore, projects that are ≤0.8 km^2 (200 acres) or linear may overlap only part of a tortoise's annual home range and the possibility that a resident tortoise was outside the project area at the time surveys were conducted must be addressed. In these cases, three additional 10-m (~30-ft) belt transects at 200-m (~655-ft) intervals parallel to and/or encircling the project area perimeter (200-m, 400-m, and 600-m from the perimeter of the project site) should be completed. Record any tortoises or sign encountered during these surveys. These transects are only used for the presence/absence determination; they are not included in the estimation of tortoise abundance within the project area.

What does the 95% confidence interval for the number of tortoises within the action area mean?

Confidence intervals are used to indicate the reliability of an estimate. The interval gives an estimated range of values, calculated from a set of sample data, which will include an unknown population parameter (in this case, the true number of tortoises within the action area) at the specified rate (e.g., 95%). A wider confidence interval indicates that less certainty is associated with the estimate (see Appendix 2). The Table 3 spreadsheet calculates the abundance and associated 95% confidence interval for the estimated number of tortoises within the project area (Buckland et al. 2001).

Acknowledgments

The USFWS Desert Tortoise Recovery Office is grateful to the many individuals and agencies that were instrumental in development and review of this revised protocol. Specifically, we thank Jim Nichols (USGS) and Tony Krzysik (Prescott Audubon Society) for assistance with concept design; Alice Karl (independent tortoise biologist) and Andrew Thompson (USFWS) for development discussion, and Lisa Benvenuti (Redlands Institute) for GIS support.

This protocol has undergone extensive review. We would like to thank the 2009/2010 USFWS desert tortoise coordination group (Ashleigh Blackford, Ray Bransfield, Michael Burroughs, Renee Chi, Brian Croft, Tannika Engelhard, Jody Fraser, Judy Hohman, Brian Novosak, Pete Sorenson, Leilani Takano, and Brian Wooldridge) for thoughts and suggestions. We would also like to thank Bob Steidl (University of Arizona), Kathy Ralls (Smithsonian National Zoo), Alice Karl (independent tortoise biologist), Ed LaRue (Circle Mountain Biological Consultants), Bill Boarman (Conservation Science Research & Consulting), Phil Medica (USGS), Paulette Conrad (NDOW), Steve Ferrand (Nevada Biological Consulting), and the California Department of Fish and Game (including Kim Nicol, Julie Vance, Scott Flint, and Becky Jones) for insightful comments on the document.

Literature Cited

Anderson, D.R. and K.P. Burham. 1996. A monitoring program for the desert tortoise. Report to the Desert Tortoise Management Oversight Group. 15pp.

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

Bulova, S.J. 1994. Patterns of burrow use by desert tortoises: gender differences and seasonal trends. Herpetological Monographs 8:133-143.

Burge, B.L. 1977. Daily and seasonal behavior, and areas utilized by the desert tortoise, *Gopherus agassizii*, in southern Nevada. Proceedings of the Desert Tortoise Council Symposium 1977:59-94.

Duda, J.J., A.J. Krzysik, and J.E. Freilich. 1999. Effects of drought on desert tortoise movement and activity. The Journal of Wildlife Management 63:1181-1192.

Freilich, J.E., K.P Burnham, C.M. Collins, and C.A. Garry. 2000. Factors affecting population assessments of desert tortoises. Conservation Biology 14:1479-1489.

Germano, D.J., R.B. Bury, T.C. Esque, T.H. Frittz, and P.A. Medica. 1994. Range and habitats of the desert tortoise. Pages 73-84 in R.B. Bury and D.J. Germano, eds. Biology of North American Tortoises. National Biology Survey Technical Report Series, Fish and Wildlife Research 13.

Harless, M.L., A.D. Walde, D.K. Delaney, L.L. Pater, W.K. Hayes. 2009. Home range, spatial overlap, and burrow use of the desert tortoise in the West Mojave Desert. Copeia 2009: 378-389.

Inman, R.D. 2008. How elusive behavior and climate influence the precision of density estimate of desert tortoise populations. Master of Science in Biology Thesis. University of Nevada, Reno.

Krzysik, A.J. 2002. A landscape sampling protocol for estimating distribution and density patterns of desert tortoises at multiple spatial scales. Chelonian Conservation and Biology 4:366-379.

Nagy, K.A., and P.A. Medica. 1986. Physiological ecology of desert tortoises. Herpetologica 42:73-92.

Nussear, K.E. and C.R. Tracy. 2007. Can modeling improve estimation of desert tortoise population densities? Ecological Applications 17:579–586.

Nussear, K.E., T.C. Esque, R.D. Inman, L. Gass, K.A. Thomas, C.S.A. Wallace, J.B. Blainey, D.M. Miller, and R.H. Webb. 2009. Modeling habitat of the desert tortoise (*Gopherus agassizii*) in the Mojave and parts of the Sonoran deserts of California, Nevada, Utah, and Arizona. U.S. Geological Survey Open-file Report 2009-1102. 18 pp.

O'Connor, M.P., L.C. Zimmerman, D.E. Ruby, S.J. Bulova, and J.R. Spotila. 1994. Home range size and movement by desert tortoises, *Gopherus agassizii*, in the eastern Mojave Desert. Herpetological Monographs 8:60-71.

U.S. Fish and Wildlife Service. 1990. Endangered and threatened wildlife and plants; determination of threatened status for the Mojave population of the desert tortoise. Federal Register 55 FR 12178-12191.

U.S. Fish and Wildlife Service. 2006. Range-wide monitoring of the Mojave population of the desert tortoise: 2001-2005 summary report. Report by the Desert Tortoise Recovery Office, U.S. Fish and Wildlife Service, Reno, Nevada. 85pp.

U.S. Fish and Wildlife Service. 2010. Draft Revised Recovery Plan for the Mojave Population of the Desert Tortoise (Gopherus agassizii). U.S. Fish and Wildlife Service Region 8, Sacramento, California.

Walde, A.D., L. Bol, D.K. Delaney, and L.L. Pater. 2003. The desert tortoise: a preliminary analysis of operative and environmental temperatures. A Report by the Construction Engineering Research Laboratory to the U.S. Fish and Wildlife Service. 18 pp.

Zimmerman, L.C., M.P. O'Connor, S.J. Bulova, J.R. Spotila, S.J. Kemp, and C.J. Salice. 1994. Thermal ecology of desert tortoise in the Eastern Mojave Desert: seasonal patterns of operative and body temperatures, and microhabitat utilization. Herpetological Monographs 8:45-59.

Appendix 1. Detailed description of desert tortoise abundance and CI estimation

The estimated abundance of adult desert tortoises within the action area is given by:

$$\begin{pmatrix}\text{Estimated number of tortoises}\\ \text{within action area}\end{pmatrix} = \frac{\begin{pmatrix}\text{Number of tortoises}\\ \text{observed above ground}\end{pmatrix}}{\begin{pmatrix}\text{Probability that}\\ \text{a tortoise is}\\ \text{above ground}\end{pmatrix}\begin{pmatrix}\text{Probability of}\\ \text{detecting a tortoise,}\\ \text{if above ground}\end{pmatrix}}\begin{pmatrix}\frac{\text{Size of action area}}{\text{Size of area surveyed}}\end{pmatrix}$$

,

which is equivalent to:

$$\hat{N} = \left[\frac{(n)}{(Table2)(0.63)}\right]\left[\frac{(A)}{(a)}\right],$$

where $\hat{N}$ = estimated abundance within entire action area, *n* = number of tortoises observed above ground, *A* = total action area, and *a* = size of actual area surveyed (= total # km surveyed * 0.01). For 100% coverage surveys, *A/a* = 1.

Table 3 uses the following equations to calculate the 95% confidence interval for the estimate of tortoise abundance within the action area (Buckland et al. 2001), assuming all replicate transect lines are the same length, 10-km.

$$\hat{\text{var}}(n) = L\sum_{i=1}^{k} l_i\left(\frac{n_i}{l_i} - \frac{n}{L}\right)^2 /(k-1)$$

where $\hat{\text{var}}(n)$ = the spatial variation in the number of tortoises detected through the total transect length L, n_i = the number of tortoises seen on transect *i*, l_i = the length of individual transect *i*, and *k* = total number of transects walked.

Putting the sources of variability together, the variance of density is:

$$\text{var}\,\hat{D} = \hat{D}^2\left[\frac{\text{var}(n)}{n^2} + \frac{\text{var}(\hat{P}_a)}{(\hat{P}_a)^2} + \frac{\text{var}(\hat{P}_d)}{(\hat{P}_d)^2}\right]$$

Because the tortoise density sampling distribution is positively skewed, the confidence interval is calculated using a log-distribution for density and built with division and multiplication, rather than addition and subtraction from the mean as with a symmetrical interval (Buckland et al. 2001).

Thus, the 95% confidence interval for $\hat{N}$ is:

$$\left(\hat{N}/C_N, \hat{N}\cdot C_N\right),$$

where $C_N = \exp\left\lfloor z_\alpha\sqrt{\text{var}(\log_e \hat{D})}\right\rfloor$ and $\text{var}(\log_e \hat{D}) = \log_e\left[1 + \frac{\text{var}(\hat{D})}{\hat{D}^2}\right]$.

Given the simplifying assumptions in this protocol, the 95% confidence interval around the estimated number of tortoises within the action area will be wide (e.g., the estimate of the number of tortoises will be imprecise). While this level of imprecision would not be appropriate for recovery planning and decision making at large scales, this protocol provides estimates at local scales that most efficiently utilize the best information that is available to provide statistically defensible results.

Appendix 2. Example

Project location = near Beatty, NV (within the Eastern Mojave RU)

Action area = 12 km^2 (3,000 acres)

According to this protocol's Site Assessment key, the proposed action is within the known range of the desert tortoise. The local USFWS and appropriate state agency offices were contacted and a species list, which includes the desert tortoise, was obtained for the action area. Therefore, pre-project survey and consultation are necessary.

The project footprint is only 10 km^2, but since the project will include blasting, the reach of the proposed action on listed species extends to 12 km^2. Thus, the action area (and therefore the area which needs to be surveyed for desert tortoises) is 12 km^2 (which is more inclusive than the 10 km^2 project footprint).

According to Table 2 of the pre-project survey protocol, the project size of 12 km^2 is above the threshold project area to allow probabilistic sampling in the Western Mojave RU (10.8 km^2 threshold). Therefore, at a minimum, 1,083 km of transects must be walked. For this example, 108 10-km transects (10-m wide) were placed systematically across the project site and were completed in a random order. Surveys of 100% coverage in which 10-m wide transects were placed across the entire 12 km^2 action area would also have been acceptable.

Transects totaling 1,083 km were conducted and 19 adult tortoises (> 160 mm carapace length) were found (as well as tortoise sign, both of which were catalogued using the USFWS 2010 DT pre-project survey protocol data sheet). If 20 adult tortoises had been encountered before the 1,083 km of transects were completed, and transects were conducted in a random order, then surveys could have been considered complete after the 20th tortoise was catalogued.

Data collected from the108 transects (live animals encountered <160-mm MCL)

Number of tortoises (n_i)	Number of transects on which n_i tortoises were seen
0	93
1	11
2	4

Using the Western Regional Climate Center website, it was determined that the Beatty area had received 97-mm (3.8 inches) of rain in the October through March preceding the survey effort, which is above the 40-mm (1.5 inches) in Table 1. Therefore, P_a of 0.80 will be used in this estimation.

Thus, from

$$\hat{N} = \left[\frac{(n)}{(Table2)(0.63)}\right]\left[\frac{(A)}{(a)}\right]$$, we get $$\hat{N} = \left[\frac{(19)}{(0.80)(0.63)}\right]\left[\frac{(12\,\text{km}^2)}{(10.8\,\text{km}^2)}\right]$$, or $\hat{N} =\sim 42$ tortoises

$$\text{Density} = \frac{(\hat{N})}{(A)}$$, we get $$\hat{D} = \frac{(42)}{(12\,\text{km}^2)}$$, or $\hat{D} =\sim 3.5$ tortoises/km^2

To calculate the 95% confidence interval for our abundance estimate, we use:

$$\hat{\text{var}}(n) = L\sum_{i=1}^{k} l_i\left(\frac{n_i}{l_i} - \frac{n}{L}\right)^2 /(k-1),$$

$$\text{we get } \hat{\text{var}}(19) = 1080\left[(93)(10)\left(\frac{0}{10} - \frac{19}{1080}\right)^2 + (11)(10)\left(\frac{1}{10} - \frac{19}{1080}\right)^2 + (4)(10)\left(\frac{2}{10} - \frac{19}{1080}\right)^2\right]/(108-1), \text{ or}$$

$$\hat{\text{var}}(19) = 23.88$$

And for,

$$\text{var}\,\hat{D} = \hat{D}^2\left[\frac{\text{var}(n)}{n^2} + \frac{\text{var}(\hat{P}_a)}{(\hat{P}_a)^2} + \frac{\text{var}(\hat{P}_d)}{(\hat{P}_d)^2}\right], \text{ we get } \text{var}\,\hat{D} = 3.5^2\left[\frac{23.88}{19^2} + \frac{0.05}{0.80^2} + \frac{0.011}{0.63^2}\right], \text{ or } \text{var}\,\hat{D} = 2.107$$

Using our log-transformation because the tortoise density sampling distribution is positively skewed,

$$\text{var}(\log_e \hat{D}) = \log_e\left[1 + \frac{\text{var}(\hat{D})}{\hat{D}^2}\right], \text{ we get } \text{var}(\log_e \hat{D}) = \log_e\left[1 + \frac{2.107}{3.5^2}\right], \text{ or } \text{var}(\log_e \hat{D}) = 0.15$$

Then,

$$C_N = \exp\left[z_\alpha\sqrt{\text{var}(\log_e \hat{D})}\right], \text{ we get } C_N = \exp\left[(1.96)\sqrt{0.15}\right], \text{ or } C_N = 2.18$$

And,

$$\left(\hat{N}/C_N, \hat{N}\cdot C_N\right), \text{ we get } \left((42/2.18), (42\cdot 2.18)\right), \text{ or } \sim(19, 92).$$

Summary

Using the Site Assessment key, it was determined that survey and consultation were necessary for the proposed action. Thus, the pre-project field survey protocol was implemented. In this case, probabilistic sampling with equal length transects (10-km long) was used and 19 adult tortoises and tortoise sign were found during the sampling of the action area, indicating presence. Using the equations and data presented in Appendix 1 of this protocol, Table 3 estimated the actual number of tortoises within the project was estimated to be ~42, with a 95% confidence interval of ~(19, 92).

USFWS 2010 DESERT TORTOISE PRE-PROJECT SURVEY DATA SHEET

Please submit a completed copy to the action agency and local USFWS office within 30-days of survey completion

Date of survey: _____ Survey biologist(s): _____
(day, month, year) (name, email, and phone number)

Site description: _____
(project name and size; general location)

County:_____ Quad:_____ Location:_____
(UTM coordinates, lat-long, and/or TRS; map datum)

Circle one: 100% coverage or Sampling Area size to be surveyed: _____ Transect #: ____ Transect length: _____

GPS Start-point: _____ _____ Start time: _____am/pm
(easting, northing, elevation in meters)

GPS End-point: _____ End time: _____am/pm
(easting, northing, elevation in meters)

Start Temp: _____ºC End Temp: _____ºC

Live Tortoises

Detection number	GPS location Easting	GPS location Northing	Time	Tortoise location (*in burrow*: all of tortoise beneath plane of burrow opening, or *not in burrow*)	Approx MCL >160-mm? (*Yes, No or Unknown*)	Existing tag # and color, if present
1						
2						
3						
4						
5						
6						
7						
8						

Tortoise Sign (burrows, scats, carcasses, etc)

Detection number	GPS location Easting	GPS location Northing	Type of sign (*burrows, scats, carcass, etc*)	Description and comments
1				
2				
3				
4				
5				
6				
7				
8				

Page: _____of_____

Transect number: _____