2010

San Diego Management and Monitoring Program

Jeff A. Tracey, PhD

Burrowing Owl Monitoring Analysis and Protocol

An analysis of burrowing owl (Athene cunicularia) occupancy in south coastal San Diego County

I. Occupancy Analysis of the 2010 Burrowing Owl Survey Data

Prepared by Jeff A. Tracey for the San Diego Association of Governments

Introduction

The overall purpose of this study was to evaluate the methodology in the monitoring protocol described in Section II. The specific purpose of the analysis presented here is to use data collected according to the burrowing owl monitoring protocol to estimate occupancy for both burrowing owls and California ground squirrels within the sample frame.

Methods

Data Collection

Data were collected by BioResource Consultants Inc. according to the protocol described in Section II. Some sites were inaccessible, unsafe to visit, or occurred in least tern breeding areas and had to be removed from the study. As a result, 19 of the 110 sites in the point sample frame (PSF) were not visited at all, thirteen sites received one visit, eleven sites received two visits, and 67 of the sites were visited all three times. Within the road sample frame, 27 of the 160 sites received no visits. The resulting data from the point sample frame used to fit the occupancy models for both burrowing owls and California ground squirrels is shown in Table 1. Within the point sample frame, burrowing owls were detected at six sites and ground squirrels were detected at sixteen sites. Within the road sample frame, burrowing owls were detected at three sites and ground squirrels were detected ad 43 sites. Owls or squirrels may have been detected at a site more than one time, as shown in Table 1.

Table 1: Summary of the occupancy data collected in the point sample frame that was used to parameterize the "basic" occupancy model for burrowing owls and ground squirrels. Twenty-seven possible detection histories are available for each site, representing all possible combinations of detection (1), failure to detect (0), and no data The observed number of each detection history and the expect number, based on the fitted occupancy model, are given for burrowing owls and ground squirrels. (-). Nineteen of the sites received no visits during the survey and some of the possible detection histories did not occur (indicated by a "-" in the observed and expected counts).

Site History			Burrowing Owl		Ground Squirrel	
Visit1	Visit2	Visit3	Observed	Expected	Observed	Expected
-	-	-	19	-	19	-
0	-	-	1	0.962843	1	0.920702
1	-	-	0	0.037157	0	0.079298
-	0	-	11	10.59127	11	10.12772
0	0	-	-	-	-	-
1	0	-	-	-	-	-
-	1	-	0	0.408731	0	0.872279
0	1	-	-	-	-	-
1	1	-	-	-	-	-
-	-	0	1	0.962843	0	0.920702
0	-	0	10	10.34628	11	9.458595
1	-	0	1	0.244991	0	0.669127
-	0	0	-	-	-	-
0	0	0	62	62.12381	53	54.48504
1	0	0	1	0.894429	3	3.126395
-	1	0	-	-	-	-
0	1	0	2	0.894429	0	3.126395
1	1	0	1	0.597791	0	0.949196
-	-	1	0	0.037157	1	0.079298
0	-	1	0	0.244991	0	0.669127
1	-	1	0	0.16374	0	0.203152
-	0	1	-	-	-	-
0	0	1	0	0.894429	8	3.126395
1	0	1	0	0.597791	0	0.949196
-	1	1	-	-	-	-
0	1	1	0	0.597791	2	0.949196
1	1	1	1	0.399533	1	0.288183

Data Analysis

In this analysis, we focus on analysis on a "basic" occupancy model that assumes a constant detection probability, p, and occupancy, ψ. Thus, this model has only two parameters. Following the formulation of Royal (2006), the likelihood function for the model is:

$$L(p,\psi \mid \mathbf{v},\mathbf{y}) = \prod_{i=1}^{n} binom(v_i, y_i, p)\psi + (1-\psi)1\{y_i = 0\} \quad (1)$$

where detection given occupancy (ψ) at site i is modeled as a binomial random variable with probability p, number of trials v_i, and number of successes y_i. Because every site did not receive three visits, the likelihood function above accounted for missing data by including the number of visits made to each site. Maximum likelihood estimates (MLEs) of the two model parameters p and ψ were obtained by fitting eq. (1) to the data from the point sample frame shown in Table 1. The model was fit for both burrowing owls and ground squirrels. A bootstrap goodness-of-fit test was performed following the method described by MacKenzie and Bailey (2004). All analyses we performed using programs written by Jeff A. Tracey in the R programming language (R Development Core Team 2009). Parameters p and ψ were constrained during optimization to ensure they remained on the interval (0, 1). Variances for the parameter estimates were computed using the observed information matrix (the technical details are omitted here).

Results

Burrowing Owl

The likelihood function was successfully fit to the data, achieving a value of $\ell(p,\psi \mid \mathbf{y})$ = 27.29684 when evaluated at the MLEs. Our estimated detection probability, $\hat{p}$, was 0.4006 with a 95 % confidence interval of (0.1558 – 0.7076; Figure 1). Our estimated occupancy, $\hat{\psi}$, was 0.0923 with a 95 % confidence interval of (0.0364 – 0.2167; Figure 1). According to our model, the probability that a site was occupied given that no owls were observed during all three visits is 0.0215, during two visits is 0.0352, and during one visit is 0.0574. Based on this, the percent area occupied (PAO) is estimated to be 9.26%. Note that this estimate applies only to the point sample frame described in Section II. Given the observed site histories and the estimates for occupancy and detection probability, we calculated the expected number of events for each site history (Table 1), from which we calculated an observed χ^2 of 7.8911. From the bootstrap goodness-of-fit test (MacKenzie and Bailey 2004) a distribution of the test statistic under the null hypotheses that the data we generated by the fitted model was simulated ($\overline{\chi}_B^2$ = 11.1552, with a 95 % confidence interval of 3.2482 – 35.3217, overdispersion parameter $\hat{c}$ = 0.7074). Based on the bootstrap goodness-of-test test, we fail to reject the null hypotheses (p-value = 0.562).

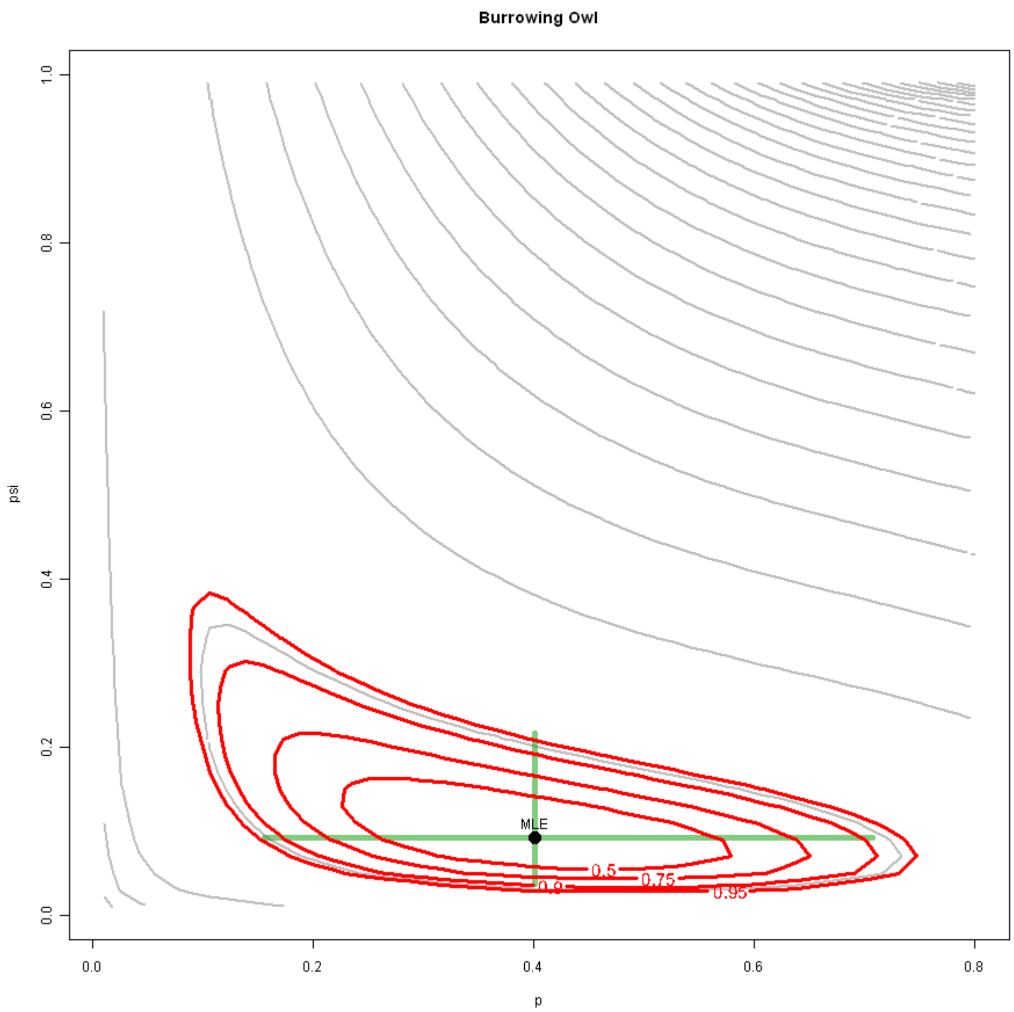

Figure 1: The negative log-likelihood surface for the burrowing owl basic occupancy model with detection probability (p) on the x-asxis and occupancy (ψ) on the y-axis. The maximum likelihood estimate (MLE) of both parameters is shown as a black point. Contours for the bivariate confidence regions are shown in red, and 95% confidence intervals for each parameter (using the observed information matrix) are shown as green bars.

California Ground Squirrel

The likelihood function was successfully fit to the data, achieving a value of $\ell(p,\psi \mid \mathbf{y})$ = 49.5388 when evaluated at the MLEs. Our estimated detection probability, $\hat{p}$, was 0.2329 with a 95 % confidence interval of (0.0971 – 0.4615; Figure 2). Our estimated occupancy, $\hat{\psi}$, was 0.3405 with a 95 % confidence interval of (0.1381 – 0.6246; Figure 2). According to our model, the probability that a site was occupied given that no squirrels were observed during all three visits is 0.1890. Given the observed site histories and the estimates for occupancy and detection probability, we calculated the expected number of events for each site history (Table 1), from which we calculated an observed χ^2 of 30.0259. From the bootstrap goodness-of-fit test (MacKenzie and Bailey 2004) a distribution of the test statistic under the null hypotheses that the data we generated by the fitted model was simulated ($\overline{\chi}_B^2$ = 10.8355, with a 95 % confidence interval of 3.6018 – 26.7102, overdispersion parameter $\hat{c}$ = 2.7711). Based on the bootstrap goodness-of-test test, we reject the null hypotheses (p-value = 0.012).

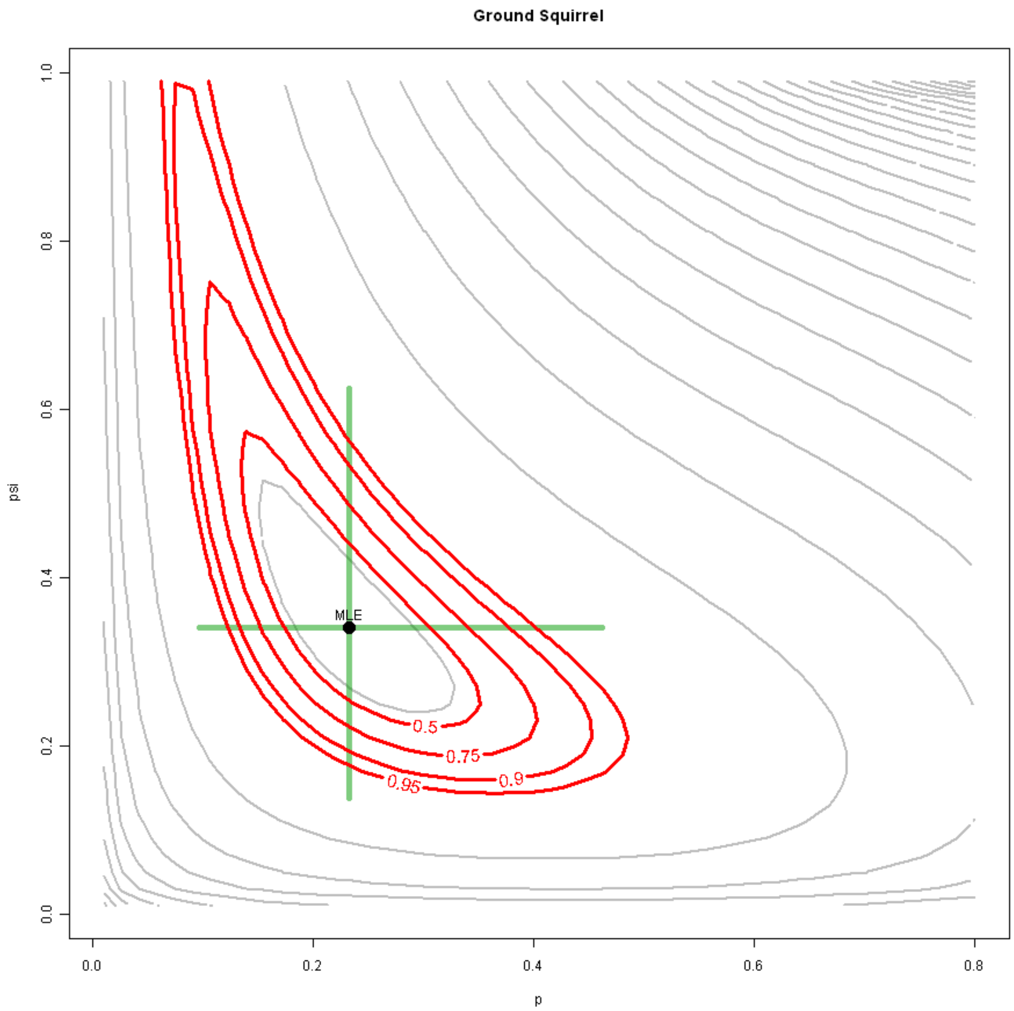

Figure 2: The negative log-likelihood surface for the ground squirrel basic occupancy model with detection probability (p) on the x-axis and occupancy (ψ) on the y-axis. The maximum likelihood estimate (MLE) of both parameters is shown as a black point. Contours for the bivariate confidence regions are shown in red, and 95% confidence intervals for each parameter (using the observed information matrix) are shown as green bars.

Discussion

The data was collected according to the protocol in Section II by BioResource Consultants Inc. Of the initial 110 sites in the point sample frame, 91 sites (83 %) were visited one or more times. Of the initial 160 sites in the road sample frame, 133 sites (83 %) were visited one or more times. In addition, many of the sites with one or more visits were visited fewer than three times. The fact the some sites were visited more than once but less than three times suggests inconsistency in the criteria used to determine whether or not a site was safe, accessible, etc. or that factors related to this determination changed during the course of the field work.

In the point sample frame (PSF), burrowing owls were detected at six (6.5%) of the 91 sites that were visited one or more times. In the road sample frame (RSF), however, owls were detected at three (2.3%) of the 133 sites that were visited one or more times. Ground squirrels were detected at 16 (17.6%) PSF sites and 43 (32.3%) RSF sites that were visited one or more times. Although not used in the analysis above, the road sample frame appears to have lower occupancy, a lower detection probability, or both for burrowing owls. However, the percent of sites in the RSF at which squirrels were detected was higher than in the PSF, based on the naïve estimate. Prior to the analysis, we expected detection probability for owls to be in the range of 0.6 to 0.9 (see Section II). However, they were much lower than anticipated, with an estimated detection probability for owls of 0.4006 and for squirrels of 0.2329. The occupancy sampling should be, as much as possible, conducted in the same manner at sites on roads and at sites in accessible lands. In general, efforts should be made in future studies to increase detection probability for both owls and squirrels. Possible ways to improve detection include (a) better training of field personnel, (b) more consistent application of the monitoring protocols, (c) changes in the protocol such as the number of visits per site or the time spent at a site during each visit, and (d) improved field equipment and consistent used of the same equipment.

Using the data from the point sample frame, we fit a basic occupancy model for burrowing owls and ground squirrels. We expected parameter estimation for this model to be successful based on simulations conducted prior to the field work. The MLEs and the associated confidence intervals for occupancy and detection probability appear reasonable based on Figure 1and Figure 2. However, for the ground squirrels, we rejected the null hypothesis that the observed detection histories were consistent with those expected from the fitted occupancy model. This is likely due to unequal detection probabilities for each visit, since about two-thirds of the detections occurred on the third visit. For the burrowing owl we estimated an occupancy of 0.0923, and a PAO of 9.23%.

If this work is to be repeated in the future, the monitoring protocol must more clearly state the following:

- The ground squirrel occupancy data must be collected as carefully as we expect the burrowing owl data to be collected. The detection probability for ground squirrels was extremely low. The protocol should more clearly describe the methods for collecting ground squirrel data, and additional data on the number of ground squirrels and ground squirrel burrows should be collected.
- At sites where burrowing owls were detected, a more thorough search should have been conducted to obtain a count of owls at the site, as described in the initial USFWS protocol. This must be stated more clearly and more completely described in the protocol.

One of the objectives was to identify habitat covariates associated with suitable burrowing owl habitat. In the present work, sites with detections were too few in number to be useful in this effort. In the future, conceptual models need to be developed to guide data collection and analysis, with attention to the spatial and temporal scale of the covariates related to habitat suitability. Appropriate methods for collecting habitat covariate data should be re-evaluated. The criteria for including sites within the sample frame may be improved, and the spatial extent of the monitoring can be increased to both increase sample size and the number of sites with detections.

References

MacKenzie, D. I. and L. L. Bailey (2004) Assessing the fit of site-occupancy models. JABES 9(3): 300 – 318.

R Development Core Team (2009). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Royal, J. A. (2006) Site Occupancy models with heterogeneous detection probabilities. Biometrics 62: 67 – 102.

II. Burrowing Owl (*Athene cunicularia*) 2010 Survey Protocol

Prepared by Jeff A. Tracey, PhD (San Diego Monitoring and Management Program) and Clark Winchell (US Fish & Wildlife Service)

Background

Study Objectives:

1. Estimate occupancy and percent area occupied (PAO) for each stratum.
2. Determine if occupancy is different in each stratum.
3. Estimate occupancy of squirrel burrows in area stratum.
4. Collect environmental covariates for analysis of burrowing owl habitat suitability.
5. Identify populations for potential adaptive management.
6. Use what we learn from this study to improve the study design for the next survey.

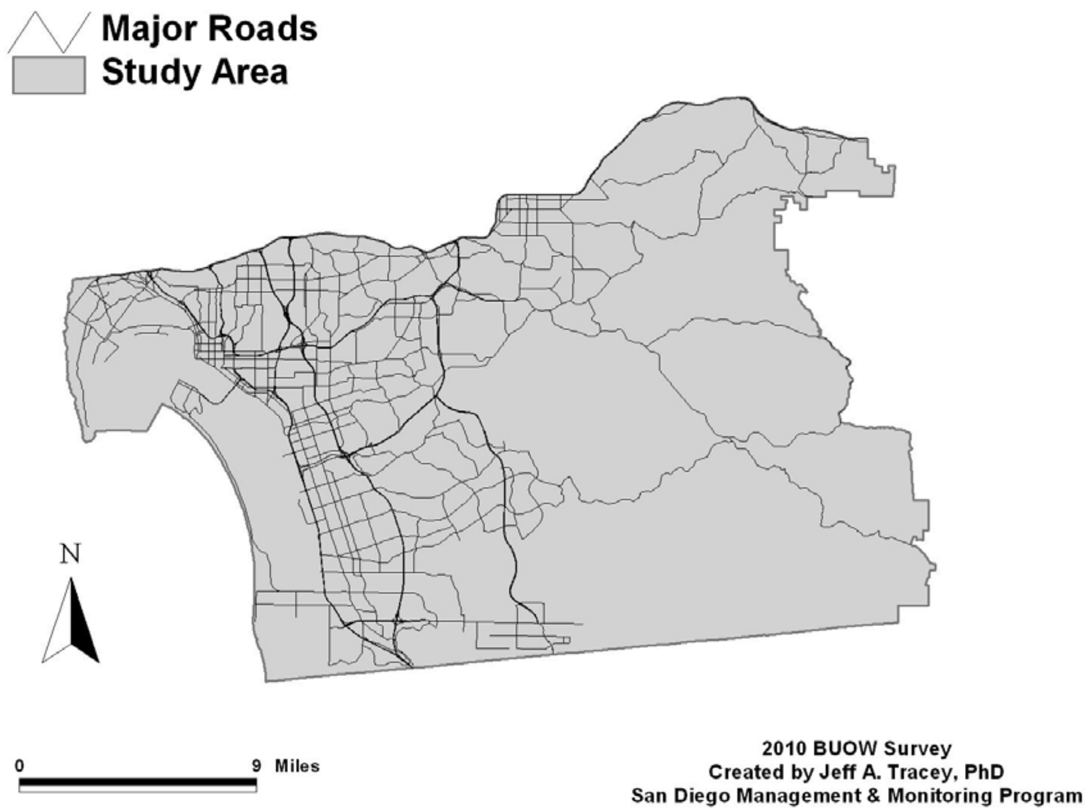

Figure 3: 2010 burrowing owl survey study area. Major roads are shown in black for reference.

Constraints on Study Design: The study design is constrained by (a) the total hours available to conduct field work and (b) areas accessible for surveys. Based on the agreement with BioResource Consultants Inc., 1920 total hours and six field biologists are available for the survey. Surveys are restricted to conserved lands and areas immediately adjacent to public roads.

Study Area: In order to accommodate the time constraint described above, we restricted the area for the survey. The study area is bounded on the north by I-8, the east by the MSCP boundary, the west by the Pacific Ocean, and the south by the US-Mexico border (Figure 3).

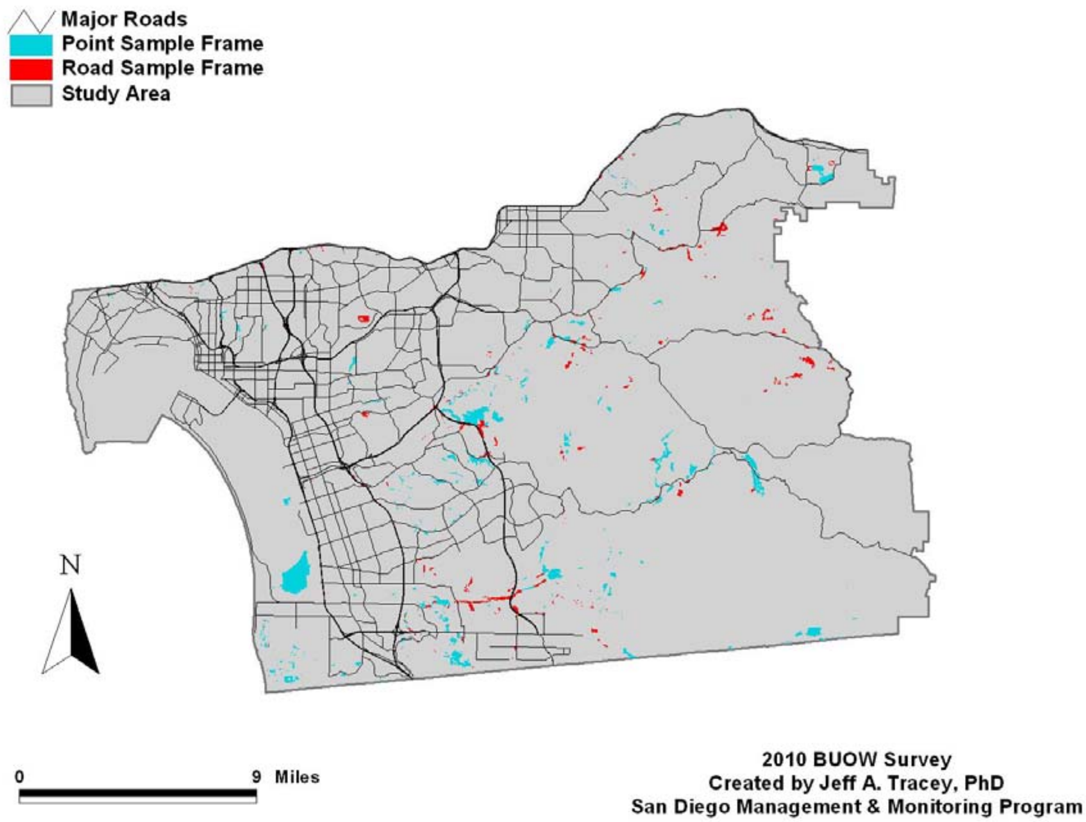

Figure 4: The Road Sample Frame (RSF, red) and Point Sample Frame (PSF, blue) within the study area.

Sample Frames: The sample frame consists of all conserved lands within the MSCP Preserve that are mapped as disturbed habitat, field/pasture, general agriculture, native grasslands, non-native grasslands, non-vegetated channel, floodway, lake shore fringe, valley needlegrass grassland, or valley and foothill grassland. In order to maximize the area available for surveys within the study site, we constructed two sampling frames: (1) a "point sample frame" (PSF) which consists of lands which are conserved and hence, accessible and (2) a "road sample frame" (RSF) which consists of areas that are adjacent to public roads and can be surveyed by collected data at pre-specified sites along the roads (Figure 4). Although sample sites were selected without regard to burn history, some sites may be located in the burn areas. Points are placed and sampled without regard to these fires, since grasslands may be the first to revegetate after a fire.

Stratification: We created three strata for the study based on vegetation cover (Figure 5). Since we do not know if occupancy differs among the strata, and one purpose of stratification is to reduce variability in the estimates within strata, one question for this study is "does occupancy differ among the strata?" Our ability to answer this question is determined by the study design, study execution, and the occupancy in each stratum. The strata are: (1) native grassland, (2) non-native grassland, and (3) disturbed (Figure 5).

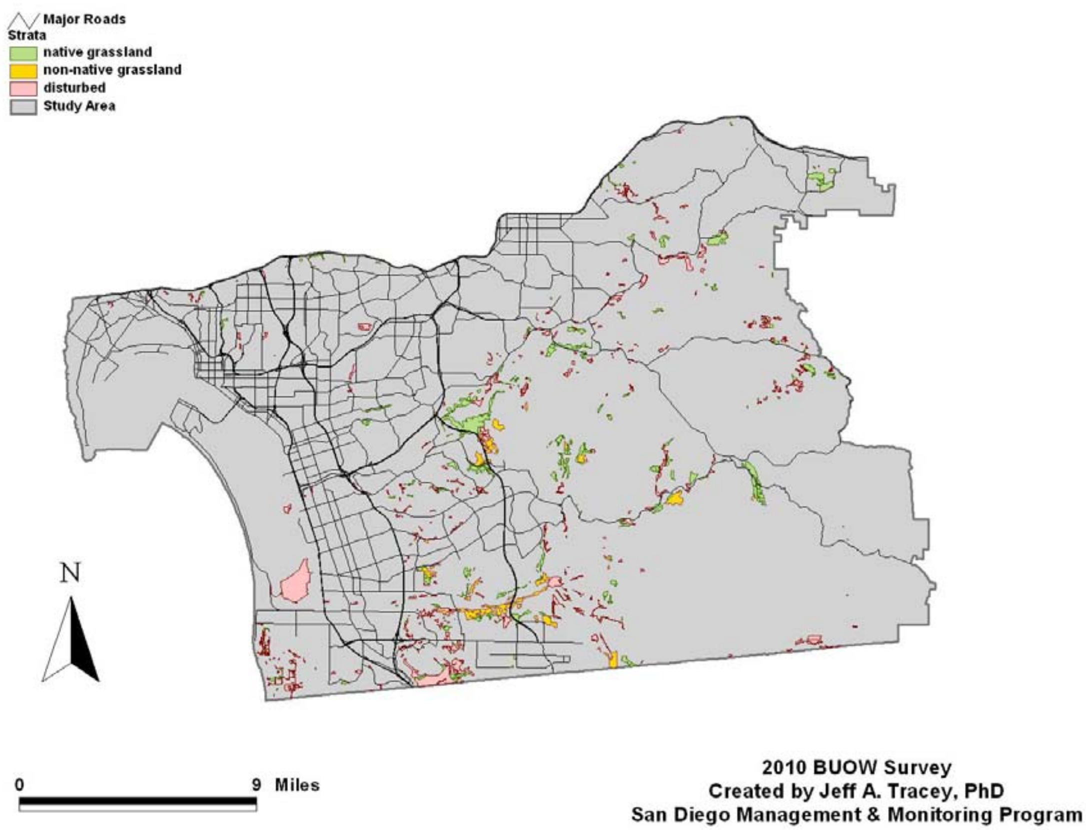

Figure 5: Stratification of the sample frames.

Table 2: Areas represented by each strum within each sample frame.

Sample Frame	Stratum	Area (hectares)*
RSF	Native grassland	2196.3
	Non-native grassland	1518.3
	Disturbed	2904.73
PSF	Native grassland	6915.8
	Non-native grassland	802.7
	Disturbed	8410.9

* Area for the RSF area based on interesting a 100m buffer of the roads with polygons for each stratum. Area for the PSF is based on intersecting conserved lands with polygons for each stratum.

Sample Units: Sites for surveys were selected with the intent to (a) avoid bias in site selection, (2) maximize coverage of the sample frames, and (c) maintain at least 400m between sample sites within each frame.

Potential sample sites were systematically generated in the PSF on a hexagonal lattice with 400m spacing. The systematic hexagonal lattice approach is similar to a grid (square lattice) except that points are arranged according to equilateral triangles to maximize packing of points while maintaining the minimum spacing between them. A higher density of sites increases the number of sites in small patches. A minimum distance of 400m between sites was selected based on the arguments presented in the USFWS Animal Monitoring Protocol (Winchell et al. 2008). Grid spacing (≥ 0.8 km) has been recommended for surveying burrowing owls in order to assure independence among sites, thus avoiding double counting (Conway and Simon 2003). However, grid spacing at distances greater than 400 m excluded most open vegetation communities in small fragmented habitats, thus creating a survey bias. Under this framework it is critical not to under sample habitats with any one particular characteristic (e.g., small patch size). Therefore, we use a spacing of 400m. Independence of samples at sites can be assessed during data analysis using join count statistics and other spatial statistics methods. A total of 110 sites fell into our point sample frame, a number of sites than can be sampled given our time constraints. Therefore, we included every site in our sample (Figure 6, Table 3; see Appendix A for reference).

Potential sample sites in the RSF were generated by placing sites at 400m intervals along the roads in the sample frame (courtesy of Grace Chung, SANDAG, using Hawth's Tools in ArcGIS). A heuristic algorithm was applied to remove sites on nearby road segments less than 400m apart. This resulted in a total of 160 sites in the RSF, all of which will be surveyed (Figure 6, Table 3; see Appendix A for reference).

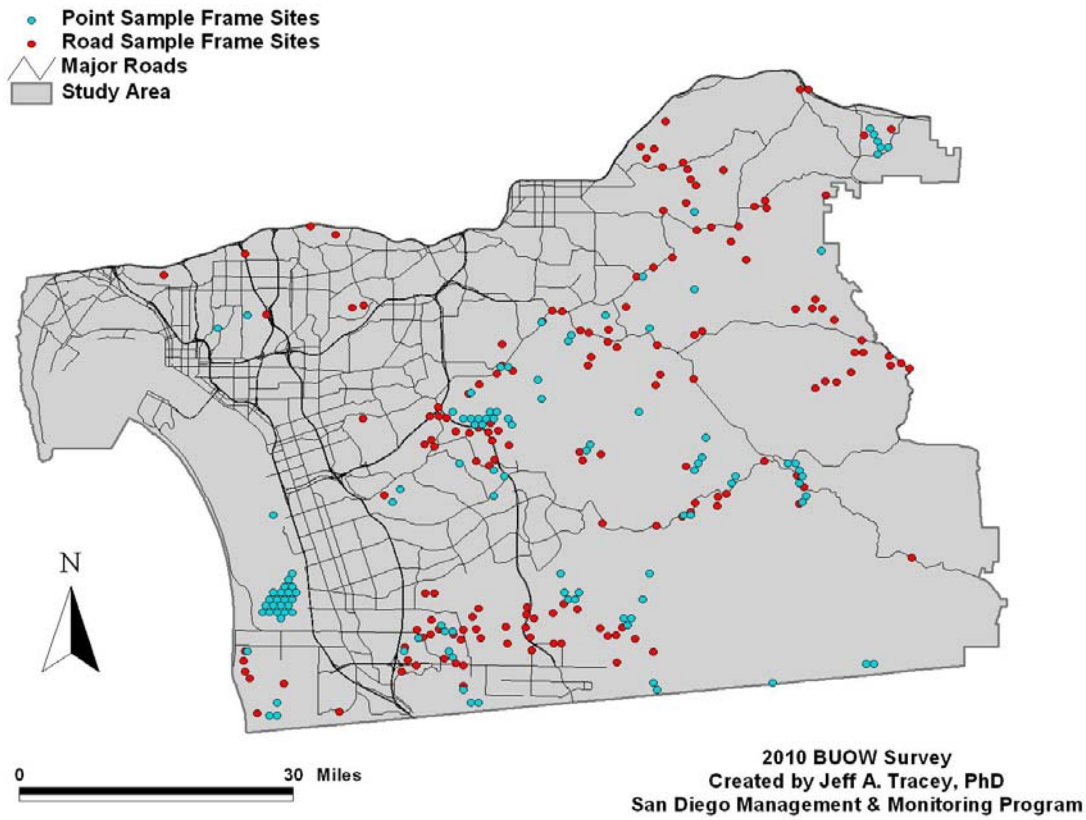

Figure 6: Sample sites selected for the burrowing owl survey. Sites in the RSF are shown in red and sites in the PSF are shown in blue.

Sample Size: The number of survey sites (sample size) and the number of visits to each site for each stratum in the PSF were determined by (a) the number of sites available, (b) a power analysis that focused on precision in occupancy estimates within each stratum, and (c) time constraints for the survey.

Our power analysis, under scenarios that have low occupancy (5%) and high detection probability (0.6 – 0.9), suggests that each site should be visited three times. We want to maximize the number of sites in the native grassland and disturbed strata given the times constraints to facilitate both the estimation of occupancy and habitat modeling. This number is based on estimates of the time required to compute burrowing owl surveys from Conway and Simon (2003) and surveys from other species (pers. comm. Clark Winchell) and is included in an Excel spreadsheet (see Appendix A for reference). Recall that 99 sites can be surveyed in native grassland stratum and 143 sites can be surveyed in the disturbed stratum (Table 3).

Table 3: Survey sites in each sample frame and stratum.

Sample Frame	Stratum	Sites to be Surveyed
RSF	Native grassland	47
	Non-native grassland	22
	Disturbed	91
PSF	Native grassland	52
	Non-native grassland	6
	Disturbed	52

Study Protocol

Sample Sites: A table of sample sites is provided as an Excel spreadsheets and as ESRI shapefiles (see Appendix A for reference).

If a site in the PSF or RSF is developed (paved, built, or landscaped), inaccessible, or unsafe, the site will be photographed and a brief explanation of why it was omitted will be provided. A site *MAY NOT* be omitted from the survey based on expert opinion of the quality of habitat or prior knowledge of burrowing owl occupancy. This will bias the results of the study. Likewise, every effort must be made to apply the data collection protocol equally (consistently) to every site regardless of expert opinion of the quality of habitat or the prior knowledge of burrowing owl occupancy.

Sampling schedule: We provide a survey schedule in order to plan the field work and randomize individual observer effects in the study. The basis of this schedule is as follows:

Each site is visited 3 times, once during each of the following 4-week time periods:

- April 4, 2010 – May 2, 2010
- May 3, 2010 – May 30, 2010
- May 31, 2010 – June 27, 2010

Burrowing owl occupancy surveys will be conducted during a four-hour period starting one-half hour before sunrise (see Appendix A for reference). The reason for this is that we want detection probabilities to be as constant as possible during the survey. Travel to and from the field, planning meetings, and data entry/QAQC can occur outside this time frame, and environmental covariate sampling can occur between 1 hour after sunrise and 1 hour before sunset.

According to the agreement with BioResource Consultants Inc., six biologists are available to conduct field work. We have labeled the "slots" in the survey schedule as

RSF1 (Road Sample Frame Biologist 1), RSF2, PSF1 (Point Sample Frame Biologist 1), PSF2, PSF3, and PSF4. Surveys in the RSF will be conducted by a two-person team (RSF1 and RSF2). Surveys in the PSF will be conducted by one individual, although two or more individuals may work a general area together (i. e. for safety or logistical reasons) but far enough apart that they do not influence the surveys at each other's sites.

The sampling schedule can be accomplished within the time constraint by, for example, working Monday – Friday, and each day having the biologists assigned to the two-person RSF team survey 12 sites in the RSF, and each of the four remaining biologists (assigned to slots PSF1, PSF2, PSF3, and PSF4) do 3 – 4 sites in the PSF. However, we leave the details of scheduling to the discretion of BioResource Consultants Inc.

Each biologist will assign themselves a unique number between 1 and 6 that they will document and retain during the duration of the field study. This number will be used to assign biologists to each slot in the survey. We have provided a table randomly assigning field biologists to survey slots in the RSF or PSF each day (see Appendix A for reference). The cycle of assignments to survey sites is repeated ach four-week survey period so that the biologist(s) that survey a site will be the same each visit so that the time to locate the site during the second and third visits is reduced. The purpose of this procedure is to rotate biologists between each survey site and among RSF and PSF surveys to randomize individual variations in detection probability.

During the first 4-week sampling period (first visit to each survey site), the order in which the sites are visited can be determined based on minimizing travel time and coordinating field activities. However, visiting the sites in a spatial pattern such as from west to east must be avoided as this will create a correlation in the time and location of site surveys. An effort should be made to avoid high-traffic roads during the busiest traffic periods during the surveys in the RSF. For the second and third 4-week period (that is, the second and third visits to the sites) the sites must be visited in the same order and schedule as the first 4-week period. This ensures the effectiveness of the random assignments of biologists to sites, and allows for a consistent time period between visits for each site). The site IDs for the sites visited each day must be recorded.

Locating Survey Sites: Survey sites will be located using a WAAS-enabled GPS unit (sub-meter accuracy is not necessary). The GPS unit must be capable of recording a track or route that can be downloaded to a GIS program. Each site will be field marked with a pin flag showing the site ID number.

Burrowing Owl Occupancy Surveys: Monitoring of burrowing owls will consist of surveys of sites under an occupancy framework (MacKenzie et al. 2006). The occupancy framework will allow estimation of the proportion of sites occupied even if not all burrowing owls are detected. The Burrowing Owl Occupancy Survey form (see Appendix for reference) will be completed during each visit to each site. Environmental covariates (data collected using the modified RHA form; see Appendix A for reference) of plots will be treated as covariates occupancy models. These analyses will evaluate how well the data support relationships between these variables and occupancy. In other words, models will be evaluated to elucidate relationships between the covariates and rates of burrowing owl occupancy. The proportion of sites occupied, along with rate at which sites become unoccupied or occupied, will be a powerful indication of the status of the species, its prospects for the future, and necessity of management action.

Burrowing owl, ground squirrel, and ground squirrel burrow presence/absence for each site will be recorded using the modified USGS SURVEY FORM (modified by USFWS; see Appendix A for reference). If an owl is located, coordinates of the location where it was first sighted will be obtained via GPS and recorded. Then, an attempt will be made to locate its likely nesting burrow within 15 minutes. If the burrow is found, the location of the burrow will also be acquired by GPS and recorded.

Logistical Summary

Survey Season: 5 April – 25 June, 2010

Survey Times: Occupancy surveys will be conducted during a four-hour period starting one-half hour before sunrise. For example, sunrise on the first day of occupancy surveys (April 5, 2010) occurs at 6:31 a. m. and the survey period will continue until 10:31 a. m. The time of sunrise for each day in the survey is provided in the survey schedule (see Appendix A for reference).

Survey Limitations: Surveys will not be conducted when wind speeds equal or exceed 16 kilometers per hour. Surveys will not be conducted during periods of rain or when relative humidity exceeds 95%.

Survey/Playback Interval: Standardized surveys will begin with a 3 minute passive segment where the observer is attempting to spot burrowing owls without the aid of playback. This initial segment will then be followed by a 3 minute call-broadcast (playback) segment. During the call-broadcast segment a call will be played at equal 30 second intervals of call/silence over the 3 minute segment. This sequence will be repeated 2 times, placing an observer 12 continuous minutes at a site. Playback will be directed at equal time intervals for each of the four cardinal directions. Playback equipment will be calibrated or checked for amplification prior to each survey. The USFWS or SANDAG will provide a standard call-broadcast recording that all surveyors will use. The volume will be set so that calls are broadcast at a level of 90 db when measured 1 meter from the playback speaker.

Number of Plots: Occupancy surveys will be conducted at every site in the RSF and PSF, for a total of 537 sites (see Appendix A for reference).

Plot Dimensions: Plot dimension will vary with topography. If conditions permit, surveys should glass the entire area within 75m radius of the point. Surveyors should remain on point while using their binoculars to glass an area. Responses to playback may reach as far as 500 m from the point (per.comm. Dan Rosenburg, Oregon State University).

Number of Surveys Per Point Per Year: Three (3) replicate surveys will be conducted at each point during the yearly survey period.

Relevant Ecology: Burrowing owls are resident (non-migratory) in San Diego County. Populations, however, increase during the non-breeding seasons as migrants from northern climates winter in southern areas that remain free of snow. Breeding and banding records indicate that breeding surveys should be conducted between 01 April and 30 July (Winchell and Pavelka 2004). Surveys during this period ensures that samples will be performed during pre-incubation, incubation/hatching, and nestling periods (the three stages of nesting).

Equipment (minimum required):
GPS (WAAS enabled)
Binoculars
Pin flags
Black permanent marking pens
Pocket Weather Monitor
Data sheets
Pens/Pencils
Sound meter that measures decibels (db)
Watch or Stop Watch
Tape playback (e.g. cassette recorder, CD player, mp3 player) capable of producing sound levels of 90 db measured 1 meter from the playback speaker.

Opportunistic Observations of Burrowing Owls and ground squirrels: If a burrowing owl or ground squirrel is detected when driving along roads in the RSF, driving to habitat in the PSF, or walking to sites in the PSF, the species, date, time, spatial coordinates, and observer name will be recorded. These observations will not be used in formal analysis of the data, but may be useful in planning future monitoring studies or adaptive management actions.

Environmental Covariate Sampling: Environmental covariates will be collected at every sample site within the PSF; however, environmental covariate sampling will NOT be conducted at sites in the RSF. Sampling will follow the modified Rapid Habitat Assessment (RHA) form and include the Simplified Key to Soil Texture protocol (see Appendix for reference).

Environmental covariate sampling will be conducted in a circular area with a radius of approximately 50m. The center of this area will be determined as follows:

- If no owl is located at a site after the third visit to a site, then the center of the sampling area will be the coordinates of the survey site.
- If one or more owls are located at the site, but no burrow is located, the center of the sampling area will be the location at which the first owl was first sighted.
- If one or more owls were located, and one or more burrows were located, then the center of the sampling area will be the location of the first burrow found.

Environmental covariate sampling may be conducted during visits to the sites for occupancy sampling, but *after* the occupancy sampling has been conducted.

Observers will complete:

- The modified USGS RAPID HABITAT ASSESSEMNT (RHA) FORM (see Appendix A for reference)
- Photo document the vegetation while they establish each sample site.

Data on moon phase, rise, and set for the San Diego area for specific days can be easily obtained from the Internet (for example, see http://www.timeanddate.com/worldclock/astronomy.html)

<u>Logistical Summary</u>

Survey Season: April 2010 – June 2010.

Survey Times: From 1.0 hr after sunrise until 1.0 hr before sunset.

Survey Limitations: Photographs are to be taken on days when cloud cover is 50% or less.

Survey Method: Complete the modified USGS RAPID HABITAT ASSESSEMNT (RHA) FORM (see Appendix A for reference) and photo document the vegetation. At each point four photographs will be taken using a digital camera. Each photograph will be orientated along one of the four cardinal ordinates, focused to infinity, position the horizon in the upper ¼ of the frame, with the camera being held perpendicular to a plum line (center of gravity).

Number of Plots: All 300 points in the PSF (see Appendix A for reference).

Plot Dimensions: Although plot dimension will vary with topography, surveys should completely record data in the area within a 50m radius of the site or location of the first owl detected at the site (if conditions permit). Conditions that may preclude surveying are highways, cliffs or private property that occurs within the 50m radius. In these or other situations, observers will document on the back of the datasheet the reason for excluding land from surveying and sketch (to scale) the surveyed area.

Equipment (minimum required):
GPS (WAAS enabled)
Pin flags
Black permanent marking pens
Measuring tape extending 5 m
Compass
Camera (digital, 6megapixels)
Data sheets
Pens/Pencils

Data Management and Reporting: All data will be entered into Excel spreadsheets, one spreadsheet each for environmental covariate sampling, one for burrowing owl (and ground squirrel) occupancy surveys, and for opportunistic sightings of burrowing owls or ground squirrels. Each column in the spreadsheets will correspond to a data field in the datasheets, and each row will correspond to an individual data sheet. At the completion of each four-week period of the field study, all data sheets and Excel spreadsheets will be provided to the San Diego Management and Monitoring Program Team and SANDAG for analysis.

Imagery from digital photographs of survey sites will be provided. A standardized naming convention will be used (and documented) for imagery files that allow the images to be referenced to the site, date, cardinal direction (N, S, E, W) in which the photo was taken, and corresponding survey datasheet.

The same coordinate system and map datum must be used for all spatial locations, and will be determined and documented prior to the start of the field study. All measurements of length and area will be provided in metric units and the specific units (e. g. m and m^2, or km and km^2) used will be the same across all biologists, datasheets, and spreadsheets and will be determined and documented prior to the start of the field study. All azimuths will be reported in degrees relative to magnetic north. All notation used in the datasheets and spreadsheets will be consistent all biologists, datasheets, and spreadsheets and will be determined and documented prior to the start of the field study. This documentation will be provided to the San Diego Management and Monitoring Program Team and SANDAG.

References

Conway, C.J. and J.C. Simon. 2003. Comparison of detection probabilities associated with burrowing owl survey methods. J. Wild. Manage. 67(3): 501-511.

MacKenzie, D. I. and others. 2006. Occupancy Estimation and Modeling. Elsevier Academic Press, Amsterdam.324 pp.

Winchell, Clark, Stacey Ostermann-Kelm, Tyler Grant, Andrew Thompson, and Guy Wagner. 2008. San Diego Multiple Species Conservation Program Animal Monitoring Protocols. US Fish & Wildlife Service. 487 pp.

Winchell, C.S. and M.A. Pavelka. 2004. Surveys to determine the home range of burrowing owls on naval air Station North Island, Naval base Coronado, Coronado, California. U.S. Fish and Wildlife Service. 90pp + Appendixes (field notes).

Appendix A: Attachments

<u>Excel files</u>

BUOW-SurveySites-2010.xls

Contains information on survey sites and alternate survey sites. Five worksheets are included:

Primary PSF Sites: Coordinates and ID numbers for all sites in the Point Sample Frame

Primary RSF Sites: Coordinates and ID numbers for all sites in the Road Sample Frame

Alternate PSF Sites-Stratum 1: Coordinates and ID numbers for alternate sites in stratum 1 (native grassland) in the Point Sample Frame

Alternate PSF Sites-Stratum 2: Coordinates and ID numbers for alternate sites in stratum 2 (non-native grassland) in the Point Sample Frame

Alternate PSF Sites-Stratum 3: Coordinates and ID numbers for alternate sites in stratum 3 (disturbed) in the Point Sample Frame

Projection Info: Information on the projection and map datum of the site coordinates (also see the *.prj file in with the shapefiles)

BUOW-SurveySchedule-2010.xls

Contains a table of random assignments of biologists to survey "slots." One worksheet is included:

Survey Schedule: Lists each survey date, the time of sunrise each survey day, and random assignment of biologists to survey sites each day.

<u>Shapefiles (minimum *.shp, *.shx, and *.dbf file for each)</u>

buow_study_area.*

The boundary of the study area

major_roads.*

Major roads within the study area

psf_sample_frame_polys.*

Polygons for each stratum within the Point Sample Frame

psf_sites.*

Points for each site within the Point Sample Frame

rsf_roads.*

Public roads within the Road Sample Frame

rsf_sample_frame_polys.*

Polygons for each stratum within the Road Sample Frame

rsf_sites.*

Points for each site within the Road Sample Frame

<u>Data Sheets/Additional Information</u>

BUOW-RHAform.doc

Data sheets for the Rapid Habitat Assessment and Occupancy Survey derived from the USFWS Animal Monitoring Protocol (Winchell et al. 2008).

BUOW-OccuonacySurveyForm.doc

Form to record information during occupancy surveys

Soil Texture Key.pdf

A simple key for identifying soil texture