

Proposal to Investigate Burrowing Owl Distribution, Abundance, and Mortality Mechanisms in the Altamont Pass Wind Resource Area

Introduction

Western Burrowing Owls (*Athene cunicularia hypugaea*) inhabit much of the western United States and southern interior of western Canada (Haug et al. 1993). They are unique among the North American owls in that they nest and roost in burrows.

A year round resident in the Altamont Pass Wind Resource Area (APWRA), burrowing owls are primarily found nesting and roosting in the lower elevation (e.g., valleys and lower portions of hill slopes) throughout much of the APWRA; however, they may forage throughout the area, including along hill slopes, hill tops, and ridges. Thus, the species may occur regularly in the vicinity of operating wind turbines in the APWRA and may be susceptible to collision mortality.

Recent monitoring results in the APWRA have suggested an unusually high incidence of burrowing owl mortality; however, the accuracy of the reported estimates and the causes of burrowing owl mortality are uncertain. While collision-related burrowing owl mortality has been previously documented, quantified, and analyzed in the APWRA with respect to turbine type, operations, and other ecological factors (Smallwood et al. 2007), the unique behavior of this species, the difficulty correlating abundance with mortality, and the relative rarity of documented fatalities combined with uncertainty regarding the extent of scavenging of carcasses, has created a significant amount of uncertainty regarding the actual levels of burrowing owl mortality in the APWRA and to what extent mortality is influenced by the presence or operation of wind turbines.

Accurately estimating turbine-related burrowing mortality will require additional information on the distribution and abundance of the species in the APWRA, investigation into the behavior of the species (e.g., the extent to which owls fly into the rotor plane of turbines and are at risk of collision), and investigation into other potential causes of mortality, primarily predation by other raptor species.

Thus, additional research exploring the distribution and abundance, behavior, and ecological relationships of the burrowing owl in the APWRA is warranted in order to fill in several data gaps and more accurately assess the potential for turbine or wind facility-related mortality. Results of this proposed study could also have application to other wind energy facilities that support burrowing owl populations.

Brief Summary of Burrowing Owl Natural History

Seasonal Patterns

Burrowing Owls are year-round residents in northern California. The breeding season (defined as from pair bonding to fledging) generally occurs from February to August with peak activity occurring from April through July (Haug et al. 1993). Pairs may be resident at breeding sites throughout the year or migrate out of the breeding area during the non-nesting season. Some individual birds migrate into northern California and only winter in the region.

Reproduction

Adults begin pair bonding and courtship in February through March. Following pair formation, a nest is established in the natal burrow and females lay a clutch of 6 to 11 eggs. Following hatching, the young remain in the natal burrow for 2 to 4 weeks after which they begin to emerge from the burrow and can be observed roosting at the burrow entrance.

After approximately 44 days, young leave the natal burrow and by 49-56 days begin to hunt live insects. On average, three to five young fledge, but fledging rates can range from a single chick to as many as eight or nine (Lutz and Plumpton 1999). During this time, the juveniles expand their range and may find cover in satellite burrows. The juveniles continue to be provisioned by the adults until mid-September when they molt into adult plumage and begin to disperse (Landry 1979).

Habitat Associations

In northern California, burrowing owls are typically found in open, dry grasslands and agricultural lands. In natural habitats, they are found nearly always in association with California ground squirrel (*Spermophilus beecheyi*), whose abandoned burrows they use for nesting and roosting sites.

Relatively sandy habitats are generally selected that allow for modification of burrows, maximize drainage, and to facilitate viewing and hunting. Typical habitats are treeless, with minimal shrub cover and woody plant encroachment, and have low vertical density of vegetation and low foliage height diversity (Plumpton and Lutz 1993). Occupied sites range from flat landscapes to hillsides, levee slopes, or other vertical cuts. Nest sites are also often associated with nearby perches, including stand pipes, fences, or other low structures. Optimal sites are within an open landscape with level to gently sloping topography, sparse or low grassland or pasture cover, and a high density of burrows. This habitat characterization is generally consistent with findings in Smallwood et al. (2007) for the APWRA.

Smallwood (pers. comm.) reports that most burrowing owl burrows in the APWRA are within relatively flat to gently rolling areas of the APWRA; however, others occur in

steeper habitats within the lower third of hill slopes with a maximum slope of approximately 45 degrees.

Burrowing Owls are solitary nesters or may nest in loose colonies – usually from 4 to 10 pairs (Zarn 1974); however, larger colonies have been documented. Most pairs occupy a natal burrow and at least one additional satellite burrow. In general, burrowing owls show a high degree of nest site fidelity and reuse the same nesting burrows and satellite burrows for many years if left undisturbed (Haug et al. 1993).

Burrowing Owls forage in open grasslands, pasturelands, agricultural fields and field edges, fallow fields, along the edges of roads and levees. Vegetation is low to maximize visibility and access. Short perches, such as fence posts are often used to enhance visibility. While they will defend the immediate vicinity of the nest, Burrowing Owls will often forage in common areas (Haug et al 1993).

Foraging Behavior and Diet

Burrowing Owls are active day and night and will hunt throughout the 24-hour day, but are mainly crepuscular, hunting mostly at dusk and dawn, and are less active in the peak of the day. They tend to hunt insects in daylight and small mammals at night. They usually hunt by walking, running, hopping along the ground, flying from a perch, hovering, and fly-catching in mid air.

Burrowing Owls opportunistically prey on large arthropods (mainly beetles and grasshoppers), small rodents, reptiles and amphibians, young cottontails, and small birds (e.g., sparrows and horned larks). Consumption of insects increases later in the breeding season as insect prey become increasingly abundant (Zarn 1974, Plumpton and Lutz 1993).

Population Trends

Overall population trend throughout the subspecies' North American range is reportedly declining. James (1993) reports that 54% of the areas sampled reported declining Burrowing Owl populations. Breeding Bird Surveys (BBS) conducted between 1980 and 1989 also report significant declines in many areas (Haug et al. 1993).

A census of Burrowing Owls from 1991 to 1993 (DeSante et al. 1997) estimated 167 nesting pairs (1.8 percent of California's population) remain in the San Francisco Bay Area, representing a decline of approximately 50% since the mid 1980s. However, the APWRA was not included in this census. In general, the APWRA is not subject to the most significant issues generally attributed to burrowing owl declines (e.g., agriculture conversion, habitat loss and fragmentation from urban encroachment), and while owls are subject to wind farm-related mortality, the APWRA provides one of the last remaining large, intact, grassland landscapes for burrowing owls in the region.

Abundance in the APWRA

Burrowing owl abundance in the APWRA has not been determined. Using a model of owl density regressed on study area size, Smallwood et al. (2007) estimated a breeding population of between 35 and 75 nesting pairs. Along with an estimate of fledglings and non-breeding floaters, they estimated a total population in the APWRA of between 208 and 446 owls at the end of the breeding season. They acknowledge, however, that the breeding population may be underestimated.

Recent surveys conducted at two locations in the APWRA suggest that the nesting population in the APWRA may be substantially higher than previously considered (Barclay pers. comm.).

Susceptibility to Collision with Wind Turbines

Smallwood et al. (2007) analyzed burrowing owl mortality data from the APWRA between 1998 and 2002. In general, the location and condition of carcasses in their study indicate that burrowing owl mortality in the APWRA is due in part to collision with wind turbines.

They also reported a total of 31 separate observations of owls flying within the rotor plane of turbines, indicating that based on observed flight behavior burrowing owls are susceptible to collision with wind turbines.

However, Smallwood et al. (2007) acknowledge two potentially complicating factors that may have influenced their results: 1) the burrowing owl population was estimated using data from outside of the APWRA and thus may be underestimated; and 2) they relied on other studies for searcher efficiency and scavenger removal rates, and thus potentially overestimated turbine-caused mortality.

Results from the ongoing monitoring study are also problematic due to the lack of abundance data, possible use of inaccurate correction factors, the relatively small number of burrowing owl fatalities recorded, and the condition of the remains (mostly feather spots) reducing certainty regarding cause of death.

Summary of Data Gaps

- Insufficient information on distribution and abundance in the APWRA. A focused area-wide survey effort will be required to more accurately characterize distribution and estimate abundance.
- Insufficient information on scavenging rates and searcher detection rates from the APWRA leading to possible inaccuracies in mortality rates for burrowing owl. Focused scavenger and searcher detection trials, or as an alternative, implementation of the SRC-recommended Data Quality Assurance/Quality Control (QA/QC) study (P98) will be required to provide more accurate correction factors.

- Uncertainty regarding cause of death due to relatively few whole carcasses suggesting that other mortality mechanisms (e.g., predation) may contribute. A focused observational study will be required to provide additional data on predation and the influence of turbines (i.e., perch sites for predators near burrowing owl colonies).
- Uncertainty regarding burrowing owl behavior around turbines and the extent to which burrowing owls are at risk of collision mortality. A focused observational study will be required to provide data on burrowing owl foraging behavior, including nighttime behavior, and to determine under what conditions burrowing owls fly into the rotor plane of turbines.

Study Plan

The following study plan was designed to address several possible data gaps related to the distribution and abundance, behavior, and other ecological relationships of burrowing owls in the APWRA.

Issues

- Mortality estimates from the recent mortality monitoring report suggests an unusually high level of burrowing owl mortality possibly suggesting a problem with the application of correction factors in the calculations.
- Mortality data also suggest that in some years there is high burrowing owl mortality occurring at non-operational turbines.
- Bird abundance surveys do not detect burrowing owls sufficient to make reliable correlations between abundance and mortality.
- Scavenging and searcher detection rates have not been established for this species in the APWRA.
- The mechanisms of burrowing owl mortality are unclear. The extent to which mortality is influenced by the presence of turbines and/or turbine operation has not been determined. Mortality could be a function of 1) collision with operating or non-operating turbines; 2) predation by other raptors (some of which may use turbines as hunting perches near burrowing owls colonies) or mammals; 3) the seasonal timing of turbine operation and habituation of owls to non-operating turbines prior to operational start-up; or 4) other non-turbine-related or background causes. This is further complicated by:
 - the lack of sufficient information on burrowing owl behavior (particularly foraging behavior – and specifically the extent to which burrowing owls fly into the rotor plane of turbines), as well as temporal (daily, seasonal) and spatial behavior patterns;
 - lack of adequate information on predators of burrowing owls in the APWRA and how predation may be facilitated around turbine rows; and

- the lack of whole carcasses that could with somewhat greater certainty reveal the cause of fatalities.

The proposed study includes investigation of the following three topics:

- Distribution and Abundance
- Behavior
- Predation

Each is described below.

1. Distribution and Abundance

Purpose: To provide a more accurate estimate of burrowing owl abundance and spatial distribution in the APWRA.

Note to SRC: please review the following. My intent was to provide a somewhat more detailed, but concise rationale for conducting this study. But it still seems a bit vague. While true, perhaps the metapopulation stuff is a bit overdone. Please provide comments, suggestions, and corrections as needed in order to tighten it up.

Current mortality data suggests a very high number of owl fatalities occurring in the APWRA each year. If collision-related mortality estimates are accurate (estimated mean of 1,208 burrowing owl fatalities per year), the APWRA burrowing owl population is unlikely to be self-sustaining over time.

The APWRA likely supports one of the most significant burrowing owl populations within the San Francisco Bay Area metapopulation. Metapopulations consist of both source populations and sink populations (i.e., incapable of sustaining their own growth). In the absence of human-caused mortality, the APWRA population would likely function as an important source population for burrowing owls, serving as a source of recruitment into other smaller breeding sites in the Bay Area. However, with the extent of mortality reported at the APWRA, this population may in fact be functioning as a sink, which could have implications regarding long-term viability of the San Francisco Bay Area metapopulation. Thus, an accurate estimation of the APWRA population is essential in assessing the reliability of mortality calculations, the long-term status of the APWRA population, and its effect on the broader regional population of burrowing owls.

In the short-term, a more precise estimate of the breeding and wintering populations in the APWRA can be used to more accurately correlate abundance and mortality (i.e., the relationship between the number of breeding and wintering owls compared with estimated fatalities) and will serve as a check on the reliability of the mortality data and correction factors used in mortality calculations. Information on distribution may result in more precise information on habitat and land use attributes (e.g., topographical characteristics, vegetation, effects of grazing intensity) and to identify high risk areas.

Long-term application would require a continuation of the monitoring program in order to correlate changes in burrowing owl abundance with mortality estimates over time. This study is therefore designed to be repeated periodically in subsequent years and assumes that mortality monitoring will also continue in the APWRA in subsequent years.

Assumptions

- A. The data collected during bird abundance surveys does not accurately reflect the population of burrowing owls in the APWRA.
- B. Burrowing owls are not evenly distributed across the APWRA landscape
- C. Burrowing owls typically occur in the APWRA under certain definable topographic conditions (slope and location on slope).
- D. The distribution and abundance of burrowing owls in the APWRA varies seasonally and annually.

Procedures

The following procedures focus on estimating overall abundance and spatial distribution of burrowing owls in the APWRA. These procedures provide a general approach that is subject to modification through continued research, discussion, and more detailed scoping by the selected contractor.

- Select survey plots.

Note to SRC: I removed the requirement to initially divide the APWRA into four geographic areas. I don't think this serves any purpose with the approach that we are now using. But please comment.

- Refer to P94 for sample and plot size determination.
 - Identify watersheds and sub-watersheds within the APWRA. Yee (P94 establishes an average watershed size of 5.16 ha).
 - To achieve statistical objective of 20% precision (i.e., margin of error \pm 20%), approximately 450 watershed-sized plots are required.
 - Note to SRC: this is where I began including the 'rule' we discussed regarding use of sub-watersheds as an alternative to selecting 450 watershed-size plots (i.e., adding contiguous sub-watersheds). But I'm having difficulty with the concept. It doesn't seem like it would actually reduce effort. Comments, suggestions?
- As an alternative to reduce effort, use an adaptive sampling approach. This approach focuses on where owls are found, and then adds adjacent survey plots.
 - Study period: the study will be conducted over a 10-month period to collect data on breeding and wintering populations. Complete surveys will be conducted

during peak periods of the breeding and wintering season: breeding season (mid-April to mid-July); and winter season (early December to late January).

- Conduct complete surveys of each plot using standard methods.
 - Standard methods include initially driving all available roads and scoping from the vehicle to identify active burrow sites and the number of individual owls.
 - Areas that cannot be sufficiently covered from the vehicle can be surveyed by walking transects and documenting active burrows, owls, and owl sign.
 - Each active burrow (burrows with observed occupancy and those with owl sign [e.g., whitewash, pellets and other prey remains, feathers]) will be recorded using GPS and mapped on field maps.
 - Surveys will be conducted during peak activity hours during the day: from two hours before sunset to one hour after, or from one hour before to two hours after sunrise to maximize detectability.
 - During the breeding season, follow-up surveys will be conducted as needed at active sites to determine the number of adult owls, the number of breeding pairs, and to determine the number of fledged young.

- Analysis: the data from all surveys will be compiled and the breeding population in the APWRA will be estimated using standard statistical procedures to estimate the number of breeding season and wintering season burrowing owls in the APWRA.

Estimated Costs

The following estimates costs primarily for purposes of annual budgeting. These costs are subject to modification through more detailed scoping and possible modifications to the assumptions or procedures.

Cost Assumptions:

- Survey area consists of 450 5 ha survey plots spread across the APWRA.
- Two surveyors complete 8 plots per 10-hour day for a total of 112 person days and a total of 1,125 survey hours per season; and a total of 2,250 survey hours for both breeding and winter season surveys.
- Pre-survey investigation and mobilization will require 40 hours.
- Data compilation, statistical analysis, and report preparation will require 160 hours.
- Average rate for all staff is \$80 per hour
- Per diem = \$23.00 per day for 225 person-days = \$5,175.
- Reimbursable expenses include vehicle use, gasoline = \$12,000.

Based on the above assumptions, the total estimated cost ranges from \$200,000 to \$225,000.

Note to SRC: this total does not factor in any savings achieved through the sub-watershed approach noted above. So, perhaps it can be reduced.

2. Behavior/Predation Study

This proposed study is designed primarily to observe burrowing owl behavior during active evening, nighttime, and early morning hours as it relates to potential turbine collision mortality. Secondly, and to the extent possible, the study will investigate the mechanisms of predation of burrowing owls.

Purpose

The primary purpose of this study is to investigate burrowing owl behavior and determine to what extent they occur within the rotor plane of turbines and would be subject to collision-related mortality. It investigates how topography and proximity influence burrowing owl behavior around turbines (e.g., are owls with burrows closer to turbines more likely to fly within the rotor plane of turbines than those that are more distant from turbines; does topography [steep slopes vs. lower rolling hills] influence the likelihood of owls flying within the rotor plane of turbines; are turbines an attractant [perch sites, more abundant prey near turbines] or a barrier?). Also, it investigates the reasons why burrowing owls fly into the rotor plane of turbines. Presumably owls are foraging during this behavior; and if so, what is the flight height and behavior of foraging owls, and what type of prey are they pursuing?

In addition, there is some speculation that a proportion of the burrowing owl mortality may be due to predation by other species, including raptors and mammals, and not directly related to collision with turbines. However, predation could be indirectly related to the presence of turbines, which provide perches to avian predators. This study is also designed to investigate the extent to which predation is occurring at burrowing owl colonies and the behavior of predators with respect to leaving prey remains that could then be included in the mortality monitoring study (are predators eating owls onsite and leaving feather spots or other remains that could be mistaken for collision-related fatalities?). Also, if significant predation is occurring, to what extent is topographical and turbine proximity conditions a factor?

Observing burrowing owl behavior can reveal the extent to which they are susceptible to turbine-related mortality. If they have high susceptibility, then the data can be used to identify specific risk factors (turbine type, rotor height, topography, proximity) that can be used to develop minimization measures (e.g., turbine removal from high risk areas, use of different types of turbines, etc.). If, however, the data indicates that they are not susceptible to collision mortality, then this suggests that some other mechanism (e.g., predation) is responsible for the high mortality estimates or that the correction factors used in estimating mortality may be inaccurate.

Assumptions

- A. Burrowing owls can forage within and around the rotor plane of operating turbines.
- B. Burrowing owls are susceptible to collision with non-operating turbines, which can cause mortality or injury.
- C. Burrowing owls can forage at any time of day, but primarily at dusk and in the first few hours of darkness, and at dawn.
- D. Burrowing owls are vulnerable to predation by nocturnal raptors, diurnal raptors and mammals.
- E. Burrowing owl predation can occur during the day or night.
- F. Burrowing owl predation may be related to activity and presence of turbines.

Procedures

The following procedures are designed to 1) gather data on how burrowing owls behave in the vicinity of turbines in the APWRA during periods of high recorded mortality, and 2) detect predation events at active burrowing owl colonies to determine the mechanisms of burrowing owl predation and whether the proximity of turbines facilitates predation.

The SRC initially recommended a pilot study to assess the effectiveness of a thermal imaging camera to detect, follow, and record burrowing movements during periods of low light. The pilot study was conducted (M28) and the SRC considered the technique reasonably effective and recommended its use to conduct this study.

- Select four survey areas with the following characteristics:
 - Vicinity of active burrowing owl colonies (i.e., areas of high burrowing density).
 - Variety of turbine types including lattice and tubular towers.
 - Sites with turbines and comparable (e.g., slopes, distance from active colony) sites without turbines.
- Identify observation sites:
 - Within each of the four survey areas, select observation sites on slopes (side of prevailing wind) with turbines along the associated ridgeline and a comparable replicate site without turbines. This equates to eight separate observation sites (or four replicates of turbine and non-turbine slopes).
 - Select observation sites that represent different turbine types (at a minimum include lattice and tubular tower turbines).
 - Divide each of the eight slopes into three elevations, high, mid, and low, for a total of three observation stations on each. This equates to a total of 24 observation stations.
- Conduct survey:
 - Randomly select the slope position (high, mid, low) each survey period.
 - Install thermally contrasting markers on the ground (e.g., pin flags) to estimate distances.

- Each slope position is surveyed using the thermal imaging camera for a two-hour period for a total of six survey hours per night using the thermal imaging camera.
 - Before the six hours of nighttime observation, conduct one hour of daytime observation using binoculars from the first selected slope location for a total of seven hours of observation per night.
 - Conduct survey for 20 nights (four replicates, each surveyed five times).
 - Simultaneously observe site with towers and its replicate site without towers; thus two thermal imaging cameras and two crews are required.
 - Using two crew members at each camera station, one operates the camera and one records owl movements and behavior and related data on field forms.
- Field staff will record data (to the extent possible) on flight behavior, foraging behavior, prey species and prey captures, other local movements, perching behavior; inter- and intra-specific interactions, proximity to wind turbines, flight height and flight type near wind turbines, presence and proximity of avian and mammal predators, predator behavior (e.g., den excavation, stooping from perch, coursing flight through colony, etc.), prey captures, and dispensation of prey (e.g., carried off whole, dismembered and eaten onsite, partially eaten onsite, etc.), and interactions between potential predators and burrowing owls.

Additional data recorded includes wind speed and direction, percent cloud cover, precipitation, temperature, time of observations.

- Survey period: preferable period is between end of November and end of January, which corresponds with period of high mortality; however, inclement weather may restrict movement in the APWRA during this time, so additional discussion on survey period is required.
- Conduct fatality searches (using standardized methods currently in use by the Monitoring Team) to encompass each elevation level of each survey site. The associated turbine string should be searched in its entirety from the ridgeline to the toe of each slope. Conduct searches following each survey (for a total of five fatality searches at each of the eight sites (turbine and non-turbine replicate) to document burrowing owl carcasses within the study area. Fatality searches at the turbine sites may provide data on actual mortality during the survey period that can be correlated with observational data; and fatality searches at the non-turbine sites can provide data on background mortality of burrowing owls that can be used to adjust correction factors in mortality calculations.

Estimated Cost

Cost Assumptions:

- Four surveyors (two per crew) are onsite for a total of nine hours per night (seven hours for surveys plus two additional hours for travel time and set-up) and a total of 36 person-hours per night. Survey is conducted for 20 nights for a total of 720 hours.
- Five complete fatality searches at each survey site (two surveyors for ten eight hour days for a total of 160 hours).
- Per diem = \$23/day for 100 person-days = \$2,300.00
- Thermal camera training (four person-days = 32 hours)
- Presurvey investigation and mobilization will require 40 hours
- Data compilation, analysis, and report preparation will require 80 hours
- Thermal camera rental (two for one month at 5,000 each per month) = \$10,000.
- Average rate for all staff is \$80 per hour.

Based on above assumptions, the total estimated cost ranges from \$95,000 to \$110,000.

Stable Isotope Analysis

Note to SRC: we did not discuss whether to retain this. Suggestions?

A related question is the natal origin of burrowing owl fatalities in the APWRA. This information would reveal whether local breeding populations or migratory populations are being affected by turbine collision or other causes of death in the APWRA. There is a procedure (stable isotope analysis) that can be used to determine the region of origin of individual birds, including burrowing owls. The required chemical analysis is often performed using the feathers of birds and comparing the stable isotopes found in the feather sample with those collected from the physical environment (e.g., rainwater, soils) of other geographic areas. Through this process, the natal origin of migratory birds can be generally determined. The monitoring team has collected several burrowing owl fatalities that can be used for this purpose. The costs for conducting this analysis are undetermined at this time.

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