Altamont Pass/
Northern Diablo Range

Western San Diego County
25 – 110 Golden Eagles killed by collisions with wind turbines in APWRA each year, 1998 – 2002
(Smallwood and Thelander 2008)
What are the cumulative, population-level consequences of turbine blade-strike fatalities?
Research Objectives

1. Characterize spatial variation in quality of breeding sites, as measured by site occupancy and reproduction of territorial pairs

2. Develop predictive spatial models of site usage by breeding and nonbreeding Golden Eagles

3. Provide recommendations to identify and monitor site quality of Golden Eagles at multiple spatial scales
Survey Design

Montezuma Hills Wind Resource Area

Altamont Pass Wind Resource Area

San Francisco Bay

San Jose

Pacheco Pass Windfarm
Survey Design

- Randomly selected 138 of 373 sites
- Survey ‘site’ = **1,385 ha hexagon**
  - based on mean territory size
- Each site searched on **4 repeated visits** during the breeding season (15 Dec – 31 July)
- On each visit, site is classified as:
  - no pair detected
  - occupied by pair with no young
  - occupied by pair with young
Eagle Survey Protocol

• 4-hr observation period each visit

• Record location, behavior, age, and pair status of all Golden Eagles - surveys also included BAEA

• Estimate “activity center” of pairs - used nest location - observations of adults with young - territorial displays

• Record number of GOEA detected (territorial adults, subadults)
Key Sources of Variation: Landscape Conditions

Vegetation Cover Type
- Grassland
- Scrub/shrub
- Mixed forest
- Developed

From Regional Landcover Database, NOAA Coastal Change Analysis Program, 2010
Weather and Drought Severity

2014

2015

2016

2018
• High-resolution (4-km) spatial climate data

• Mean precipitation and max temperature:
  - pre-nesting
  - brood-rearing
  - prior year (lag effect)
Data Analysis: Site Occupancy and Intensity of Use

- Multistate site-occupancy models
  - site-specific occupancy and reproduction
  - account for imperfect detection

- N-mixture models
  - counts of GOEA detections (pairs, subadults)
  - intensity of use of survey plots
  - account for imperfect detection

MacKenzie et al. 2017
Survey Results, 2014 – 2018

- 138 sample sites surveyed on 1,238 occasions
- 102 territorial pairs identified at 89 focal sites (mean = 1.1 pairs/site)
- 99 additional pairs identified in adjacent, non-focal sites
- Total territorial pairs detected = 201
Density of Territorial Pairs
(*naïve, uncorrected estimates*)

- Alaska, USA: McIntyre and Adams 1999
- S. California, USA: Dixon 1937
- Idaho, USA: Kochert 1972
- Wyoming, USA: Phillips et al. 1984
- E Highlands, Scotland: Watson and Rothery 1986
- Diablo Range, CA: Wiens et al. 2015
Detection of Territorial Pairs

Survey period

- courtship
- incubation
- nestling
- fledgling

Probability of detection \( (p1, p2) \)

Reproductive pairs \( (p2) \)
Nonreproductive pairs \( (p1) \)
Influence of Landscape Conditions on Site Occupancy

Intermediate amounts of grassland with patches of mixed-oak woodlands

Rugged terrain conditions
Detecting Nests and Young

- Probability of correctly identifying reproduction ($\delta$)
  - With historical data
  - Without historical data

Survey period:
1. courtship
2. incubation
3. nestling
4. fledgling
Nesting success was greatest at sites with more rainfall in drought years (2014 – 2016)

![Graph showing the relationship between mean amount of precipitation (mm) and probability of reproduction (R^2). The graph indicates that nesting success increases with higher precipitation levels.]

- Probability of Reproduction (R^2)
- Mean amount of precipitation (mm)
Sites with successful reproduction, 2015

Mean precipitation (cm)
- 12.6 - 24.6
- 24.6 - 34.9
- 34.9 - 43.9
- 43.9 - 56.6
- 56.6 - 76.2
Naïve vs. Corrected Estimates

Parameter Estimate

- Occupancy - naïve
- Occupancy - model
- Reproduction - naïve
- Reproduction - model

2014  2015  2016
Spatial Patterns in Landscape Occupancy and Reproduction

A
Predicted probability of occupancy

B
Predicted probability of reproduction, 2015

C
Predicted probability of reproduction, 2016

- ≥1 pair detected
- No pair detected
- Occupied with reproduction
- Occupied with no reproduction
- Occupied with reproduction
- Occupied with no reproduction

RESEARCH ARTICLE
Spatial patterns in occupancy and reproduction of Golden Eagles during drought: Prospects for conservation in changing environments

J. David Wiens, Patrick S. Kolar, W. Grainger Hunt, Teresa Hunt, Mark R. Fuller, and Douglas A. Bell
Conclusions and Benefits of the Study Design

• Provided a means for using monitoring data to quantify changes in site-occupancy/use and factors driving changes over time.

• Strong evidence of non-random spatial distribution of landscape occupancy and reproduction

• Survey design effective for identifying and monitoring “hotspots” of occupancy, reproduction, and site-usage at broad spatial scales

• Identified and mapped specific areas where conservation and mitigation actions can be most effectively placed