

# Windmill Noise Affects California Ground Squirrel Antipredator Behavior

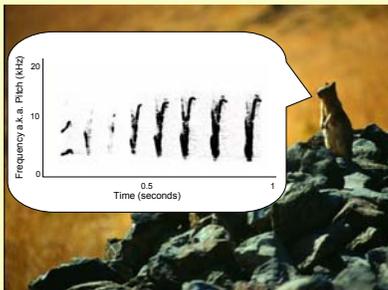
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## Background

- During the past 25 years, electricity-generating windmills have been developed to reduce our dependence on fossil fuels that use natural resources, degrade air quality, and contribute to climate change.
- Approximately 4700 electricity-generating windmills are installed in the Altamont Pass in Northern California.
- These windmills provide power to an average of 500,000 homes.
- Some environmental impacts of windmills have been identified. During 1994 for example, 348 birds of prey flew into rotating windmill blades and died as a result. 35 of these fatalities were golden eagles, a species of special concern.
- The loud noise that windmills produce during operation may have additional impacts on wildlife.
- If measures are taken to reduce impacts in the future, it can only increase the attractiveness of wind energy as a viable alternative energy source.
- The research presented here is the first study to demonstrate an impact of windmill noise on one species of wildlife, the California ground squirrel.

## Rationale

- California ground squirrels are highly vocal and depend on acoustic communication to avoid predation.
- California ground squirrels emit antipredator calls that warn other ground squirrels when predators are nearby (See Figure 1). This allows animals to take evasive action in order to avoid being eaten.
- Communicative interference near windmills due to windmill noise, has the potential to challenge survival because squirrels may detect predators less quickly and thus, experience higher levels of predation.
- In response to windmill noise, squirrels might increase visual antipredator behavior to compensate for their lesser ability to hear the acoustic antipredator calls of other ground squirrels.



**Figure 1:** California ground squirrel emitting a 'chatter' antipredator call. Chatters are typically given in response to predators approaching on the ground.

## Objectives

- To quantify differences in noise levels at Windmill and Non-Windmill Sites.
- To determine if California ground squirrels show higher levels of visual antipredator behavior at Windmill sites when compared with Non-Windmill sites due to acoustic interference caused by windmill noise.

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## Methods

- California Ground Squirrels were studied at two sites in oak-savanna ecosystems (See Figures 2 and 3): one adjacent to a string of windmills (Windmill site) and one where turbines were absent (Control site).
- Each focal squirrel's behavior was recorded twice on video, once during a 5 minute baseline sample and again during a 5 minute playback of a California ground squirrel antipredator vocalization.
- Antipredator and other related behaviors were later coded in the lab from videotapes.
- From these coded behaviors (e.g. Head Up, Head Down, Post, Feeding, At Burrow), composite variables were generated using Principles Components Analysis.
- A composite variable indicative of general alertness was generated which was then analyzed to test for differences in behavior between the Windmill and Control site.
- Acoustic measurements were also taken at each site to quantify windmill noise.



**Figure 2:** Windmill Study Site

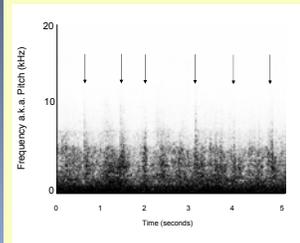


**Figure 3:** Control (a.k.a. Non-Windmill) Study Site

## How Loud is Noise Near Windmills?

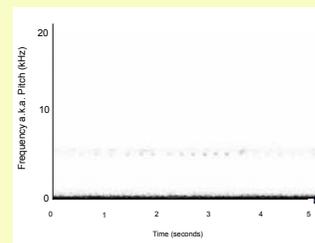
- Noise at Windmill sites (See Figure 4) is much louder than at comparable Non-Windmill sites (See Figure 5).
- Windmill noise levels are louder than those reported near Kennedy Airport, New York when subsonic jets are operating.

**Windmill Site Noise Average = 110.2 decibels**  
(measurements taken when windmills were operating)



**Figure 4:** Sonogram of Ambient Noise at Windmill Study Site. Arrows represent 'swooshing' sound of rotating turbine blades.

**Control Site Noise Average = 79.8 decibels**



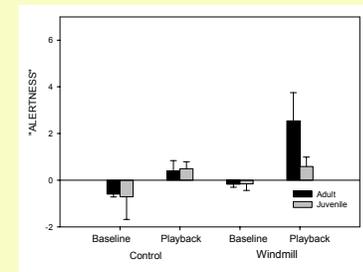
**Figure 5:** Sonogram of Ambient Noise at Control (a.k.a. Non-Windmill) Study Site

**HEAR WINDMILL NOISE  
AND GROUND SQUIRREL CALLS  
USING THE HEADPHONES**



## Higher Squirrel Alertness at Windmill Site

- California ground squirrels show higher levels of Alertness at the Windmill Site (see Figure 6) when compared with the Control site (Repeated Measures Analysis of Variance,  $p < 0.05$ ).
- Alertness is higher at the Windmill site even though predator abundance, distance to refuge, vegetation, and group size do not differ significantly between the two sites. The main difference between the Windmill and Control site appears to be noise.
- It is likely that squirrels emphasize visual behavior (in the form of Alertness) more at the Windmill site because it is difficult to accurately assess acoustic antipredator calls that may be masked by windmill noise.
- Though not yet tested, heightened levels of Alertness may have negative impacts on ground squirrels because vigilance or alert behavior is incompatible with other behaviors (e.g. foraging and social behavior) essential in ground squirrel daily activity.



**Figure 6:** Alertness at Control and Windmill Sites during baseline conditions and during the playback of alarm call series. Overall levels of Alertness are significantly higher at the Turbine Site than at the Control Site (Repeated measures ANOVA,  $p < 0.05$ ).

## Implications

### For species of special concern:

- Though some consider California ground squirrels a nuisance, they are an important part of oak-savanna ecosystems.
- Many species of special concern rely on California ground squirrels and their burrows for food and for shelter.
  - 25% of golden eagle diet is made up of California ground squirrels.
  - Burrowing owls, red legged frogs, and California tiger salamanders all use California ground squirrel burrows for shelter.
- Alteration in ground squirrel behavior and subsequent population level changes may have important community level effects by indirectly impacting these species of special concern.
- Though California ground squirrels have generally been able to cope well under environmental perturbations, this research might be used as a model to test the impacts of windmill noise on other, more sensitive species that live near windmills and use sound to communicate (e.g. kit foxes).

### For the community and decision-makers:

- Wind power is clearly a lower impact energy source than fossil fuels. In 2000 and 2001 combined, wind energy in California offset the emission of 0.84-1.68 million kg of carbon dioxide, 11.8 million kg of sulfur, nitrogen oxides and particulates, and more than 0.34 million kg of solid waste.
- However, as we continue to develop new windmills and install new windfarms, we should act to reduce any identified impacts that windmills have on California's native ecosystems and its resources.
- Because California is a leader in harvesting wind energy, it is important that we act to carefully investigate the pros and cons of current windmill models and installations so as to develop lower-impact models in the future.

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