American Badger (*Taxidea taxus*) & Western Burrowing Owl (*Athene cunicularia hypugaea*)

Climate Change Vulnerability Assessment for the Santa Cruz Mountains Climate Adaptation Project

This document represents an initial evaluation of mid-century climate change vulnerability for American badgers and burrowing owls in the Santa Cruz Mountains region based on expert input during an October 2019 vulnerability assessment workshop as well as information in the scientific literature.

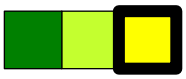
Species Description

American badgers (*Taxidea taxus*) are semi-fossorial (i.e., burrowing) members of the weasel family (Mustelidae), and are uniquely adapted among carnivores to dig for their prey and for daytime denning[1,2]. In the San Francisco Bay Area, badgers can be found where there are large areas of contiguous habitat with suitable prey, generally either extensive grasslands or grassland within a mosaic of other habitat types[2,3]. They primarily prey on burrowing mammals by digging them out of the ground, but they will also take small mammals, birds, insects, and carrion above ground[1].

The western burrowing owl (*Athene cunicularia hypugea*) occurs as a summer resident in the great plains and intermontane region of western North America and as a year-round resident from central California to east Texas and south into Mexico[4]. Within the study area, they breed in open grasslands with short vegetation, mostly at low elevations around the edge of the San Francisco Bay[2]. The burrowing owl is the only species of owl that nests in burrows that have been dug and subsequently abandoned by fossorial mammals such as California ground squirrels (*Otospermophilius beecheyi*)[2,5]. Burrowing owls eat mostly insects and other invertebrates caught on or near the ground but will also take a variety of vertebrates including rodents, birds, frogs, and lizards[6].

Vulnerability Ranking

High Vulnerability



Mod Confidence

Badgers and burrowing owls are sensitive to changes in climate factors (e.g., precipitation, soil moisture, drought, air temperature, sea level rise) and disturbance regimes (e.g., flooding) that reduce burrow availability and/or suitability, as well as those that influence prey populations. Climate-driven changes in flooding and disease may also increase mortality rates or reduce reproductive success in these species. Non-climate stressors (e.g., land-use conversion, roads/highways, livestock grazing, poisons, human recreation) can further exacerbate the sensitivity of these species by causing habitat loss, reduced reproductive success, and/or direct mortality.

Although badgers and burrowing owls are widespread in the western U.S., both species are experiencing population declines in California, particularly in more developed areas. In general, badgers display high trait variability and behavioral plasticity, but their low reproductive potential and high rates of juvenile mortality result in slow population recovery following disturbances. They also are relatively unknown and underappreciated by the public, and can be considered a nuisance species. By contrast, burrowing owls have a narrowly-defined life history, but are well-known by the public and generally receive high societal support for management. Both species would benefit from further research on management strategies to increase resilience to climate change.

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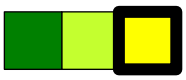
Sensitivity and Exposure

High Impact



Mod Confidence

Sensitivity is a measure of whether and how a species is likely to be affected by a given change in climate and climate-driven factors, changes in disturbance regimes, and non-climate stressors. **Exposure** is a measure of how much change in these factors a species is likely to experience.

Sensitivity and future exposure to climate and climate-driven factors

Badgers and burrowing owls are sensitive to changes in climate factors that reduce burrow availability and/or suitability, as well as those that influence prey populations.

Climate Stressor	Trend Direction	Projected Future Changes
Precipitation	▲▼	• Shorter winters and longer, drier summers likely, with higher interannual variability[7,8]
Soil moisture	▼	• Reduced soil moisture likely due to increased evaporative demand[7,9]
Drought	▲	• Increased frequency of drought years, including periods of prolonged and/or severe drought[7,10]
Air temperature	▲	• 1.5–3.1°C (2.7–5.6°F) increase in annual mean temperature[11,12]
Sea level rise	▲	• High likelihood (67% probability) of 0.2–0.3 m (0.6–1.1 ft) sea level rise by 2050[13–15]

- **Changes in patterns of precipitation (e.g., amount and timing), reduced soil moisture, and increased drought** may impact badgers by reducing prey populations[2]. For instance, drought is associated with increases in disease outbreaks that affect California ground squirrels, with the potential for extreme population reductions[2]. Dwindling prey populations are likely to reduce badger fitness and reproduction, and also puts them at greater risk for vehicle collisions by requiring them to hunt over greater distances[2].
  Reproductive success in burrowing owls has been lower in the San Francisco Bay Area following extremely wet winters[2], which are projected to increase under future climate conditions[7,8]. This may be due to reduced burrow availability and/or changes in microclimate[2]. By contrast, drought may benefit burrowing owls in the short-term[2].
- **Warmer air temperatures** are likely to impact burrowing owls by increasing burrow temperatures beyond the optimal range[2]. Studies of artificial burrows at high temperatures suggest that this may result in smaller clutch size, lower hatching rate, more asynchronous hatching, and higher fledgling mortality[2].
- **Sea level rise** may result in more frequent flooding of burrowing owl nests in the San Francisco Bay Area, as most burrows occur at low elevations near the bay[2].

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Sensitivity and future exposure to climate-driven changes in disturbance regimes


Badgers and burrowing owls are sensitive to changes in disturbance regimes that directly impact survival as well as those that reduce burrow availability.

Disturbance Regimes	Trend Direction	Projected Future Changes
Disease	▲	• Likely increases in disease associated with warmer temperatures and increased climate variability
Storms & flooding	▲	• Increased storm intensity and duration, resulting in more frequent extreme precipitation events and flooding[7,16,17]

- Badgers are susceptible to climate-driven increases in **diseases** such as canine distemper virus[18], and studies suggest that climate extremes (e.g., drought) could be associated with increased distemper epidemics in other species[19]. Climate variability has also been associated with outbreaks of plague (*Yersinia pestis*), a disease caused by flea-borne bacterium[20,21]. This disease has the potential to cause very high rates of mortality within California ground squirrels, a primary prey species for badger.
- **Increased storms and associated flooding** may cause mortality of badger kits within their natal dens. Additionally, flooding can result in unsuitable soils for non-breeding badger dens[2].

Dependency on habitat and/or other species


Badgers utilize a wide variety of open habitats (e.g., grasslands, shrublands), and are opportunistic predators within their primary food base of burrowing small mammals[22–24]. However, changes in prey availability associated with shifting vegetation phenology may reduce food resources for young[2].

Burrowing owls also have a relatively broad diet[6]. Unlike badgers, however, they are dependent on abandoned burrows with an appropriate diameter (at least 11 cm [4.3 in] wide) for nesting. During the winter, both resident owls and migrating owls that breed farther north roost in smaller burrows, enabling them to use sites that would be unsuitable for nesting.[2]

Sensitivity and current exposure to non-climate stressors


Non-climate stressors can exacerbate species group sensitivity to changes in climate factors and disturbance regimes by causing habitat loss, reduced reproductive success, and/or direct mortality.

- **Residential/commercial development** and **agriculture** results in habitat loss and fragmentation, and are specifically associated with the loss of burrows and population declines or local extirpation[2,3]. For burrowing owls, this may lead to reduced reproductive success as owls are forced to use less optimal burrows or burrow locations[2]. Badgers may also be displaced and/or controlled as a nuisance species where they come into contact with agriculture and other human-associated landscapes[2].
- **Roads and highways** are associated with vehicle collisions in Bay Area badger populations[3], due to factors such as poor eyesight, nocturnal behavior, and short legs that prevent them from climbing over road dividers[2]. Juvenile badgers, in particular, experience high rates of mortality due to vehicle strikes[2].
- **Livestock grazing** can benefit burrowing owls by keeping vegetation short[25], but negative impacts to this species can occur where ranchers eradicate ground squirrels or fill burrows[2].

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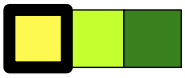
- Badgers and burrowing owls have a high risk of exposure to **anticoagulant rodenticides**, particularly through secondary exposure as they consume prey that have been poisoned[3,24,26,27]. Rodenticides can cause direct mortality[26] as well as sublethal impacts that may affect survival and fitness such as reduced ability to hunt or dig adequate shelter and impair avoidance behavior, which increases susceptibility to predation and/or road kills[2].
- Burrowing owls are easily disturbed by **recreational activities** that result in close proximity to people (e.g., photographers, birders). Disturbed owls may be unable to feed and protect chicks at nesting burrows and/or may abandon nests altogether[2].

Sensitivity to other critical factors

Climate-driven changes in the abundance of predators (e.g., coyotes) may impact badgers, potentially increasing mortality where predator populations increase[2].

Adaptive Capacity

Low Adaptive Capacity



Mod Confidence

Adaptive capacity is the ability of a species to accommodate or cope with climate change impacts with minimal disruption.

Species extent, integrity, connectivity, and dispersal ability

Badgers are widely distributed across grasslands, sage scrub, and open stages of other habitat types throughout the Great Plains and western North America[1]. The current statewide distribution of this species is not well understood. They appear to be widespread in undeveloped areas, including in the San Francisco Bay Area and Santa Cruz Mountains, but it is unknown how continuous their range is[2]. Population declines have been observed, and they are currently listed as a species of special concern in California[28]. Among carnivores that reside in urban/suburban areas of California, badgers are considered quite sensitive to habitat fragmentation and require patches that are larger than would be predicted by their body size[29]. However, they can persist in some suburban fragments, particularly where road density is low[3]. In addition to the impacts of land-use conversion and roads on habitat continuity, badger movement and dispersal is likely limited by rugged terrain (e.g., steep slopes), which is difficult for them to traverse given their short legs[2].

Western burrowing owls are also found across much of Mexico, the western U.S., and small portions of Canada. However, they are declining throughout their geographic range, and are listed as threatened, endangered, or of conservation concern in many areas. In California, they have been listed as a species of special concern since the 1980s, and populations have continued to decline since then. Land-use conversion is the primary driver of habitat fragmentation for burrowing owls[2].

Intraspecific/life history diversity

Badgers display high variability in ecological traits (e.g., abundance, territoriality, habitat selection) across their North American range[30]. Within the Santa Cruz Mountains region, they are known to utilize fragmented habitats, indicating some degree of behavioral plasticity[3].

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Although burrowing owls have a narrowly-defined life history strategy, they readily use artificial burrows for nesting[31]. Genetic diversity is likely low in the small San Francisco Bay Area breeding population, but it is not known in detail[2].

Resistance and recovery

Badgers likely live at low population densities and have large range sizes and dispersal distances[23,32]. Juvenile mortality rates are high, and females only breed every other year[23]. Additionally, there is evidence that older animals are more fecund than younger ones. All of these factors make them, like many carnivores, vulnerable to extirpation[2].

Climate change refugia for badgers may occur in higher-elevation grasslands as water availability and prey populations decline in warmer, drier low-elevation areas. Refugia for burrowing owls is currently unknown.

Management potential

Few people in California know anything about badgers, or that they even occur in the state[2]. When informed, the public in general seems interested and has a positive response. However, there is a still some belief amongst farmers and cattle ranchers that badgers are nuisance species due to concern that stock animals will break legs in burrows (although there is no empirical evidence to support this)[2]. Support for the management and conservation of badger populations is influenced by Bay Area biologists and agencies such as the California Department of Fish and Wildlife, as well as local advocates[2]. Additionally, badgers are covered species within several Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs)[2]. Conflicts can arise where badgers may be predators of special-status species, and funding generally goes toward more prominent species (e.g., mountain lions [*Puma concolor*]) or those that have formal regulatory protection through the state or federal Endangered Species Acts[2]. There is a very limited amount of actionable data on badgers statewide, and more information is needed about badgers and their habitat needs in order to determine how best to manage this species under changing climate conditions[2].

Burrowing owls are popular as charismatic mesofauna, especially when they have chicks around the entrance of the burrow[2]. Support for management of this species can be variable among North American regions, but is generally high. Within the San Francisco Bay Area, support comes from the Santa Clara Valley Habitat Agency, which funds owl conservation through fees on development within potential owl habitat areas. However, continued development has led to almost no options for protecting additional habitat beyond the 4–5 remaining breeding sites, particularly given the lack of state-listing as threatened or endangered[2]. Owls are known to breed within artificial burrows, which creates the potential for expansion into protected habitat areas that are otherwise suitable[2]. The likelihood of alleviating climate impacts on burrowing owls through habitat management or other conservation measures is unknown[2].

Recommended Citation

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Further information on the Santa Cruz Mountains Climate Adaptation Project is available on the project page (http://ecoadapt.org/programs/awareness-to-action/santa-cruz-mountains).

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