Bats

Northern California Climate Change Vulnerability Assessment Summary

Habitat Description

Northwestern California is home to many sensitive bat species such as the Townsend's big-eared bat (*Corynorhinus townsendii*), fringed myotis (*Myotis thysanodes*), long-eared myotis (*M. evotis*), western red bat (*Lasiurus blossevillii*), and pallid bat (*Antrozous pallidus*). More widespread species include California myotis (*M. californicus*), silver-haired bat (*Lasionycteris noctivagans*), big brown bat (*Eptesicus fuscus*), and little brown bat (*M. lucifugus*), among others.

Sensitivity and Exposure

Climate stressors and disturbance regimes

Bats are sensitive to climate stressors and disturbances that reduce water availability, increase energy expenditures, decrease prey availability, and interfere with hibernation.

- **Warmer air temperatures** have been associated with changes in bat migration patterns for some species (Adams 2018). However, rapid shifts in plant and insect phenology may outpace shifts in the timing of migration and breeding (e.g., Mayor et al. 2017), with a mismatch between migration, parturition (i.e., birth), and peak food availability, potentially resulting in reproductive failure or starvation (Sherwin et al. 2013). Increasing winter temperatures may also reduce torpor depth and duration in hibernating bats, which could deplete fat reserves and potentially leave bats more susceptible to fungal infections (Jones et al. 2009).
- **More frequent heat waves** may cause mortality due to overheating (i.e., hyperthermia), particularly for young bats that are more sensitive to high temperatures (Jones et al. 2009; O'Shea et al. 2016). Indirectly, heat waves may be associated with the drying of water sources and reduced food supplies (O'Shea et al. 2016).
- **Changes in precipitation patterns** and **increased drought** are likely to impact bat reproductive success, which is closely tied to water availability for lactating females (Adams & Hayes 2008; Adams 2010). Drier overall conditions are likely to reduce the extent of water sources, requiring bats to travel longer distances to reach water even as higher rates of evaporative water loss increase the frequency of visits (Adams & Hayes 2008). Bats that favor xeric forests may be particularly at risk (Adams & Hayes 2008; Adams 2010). Drought may also drive reductions in insect reproduction, leading to lower prey availability (Jones et al. 2009).
- The **exotic pathogen** *Pseudogymnoascus destructans*, a fungal disease from Eurasia, causes the fatal white-nose syndrome that has killed millions of bats since its discovery on the east coast in 2006 (Blehert et al. 2009). Although this disease is most prevalent in the eastern and central U.S., it has been reported in Washington (Lorch et al. 2016). In 2018 and 2019, white-nose syndrome was found in a little brown bat maternity colony in Plumas County, California (CDFW & USFWS 2019), suggesting that the disease remains a threat to northern California bats. However, research provides conflicting information about the effects of warmer temperatures on white-nose syndrome, with studies suggesting that higher temperatures and humidity are associated with both higher (Flory et al. 2012) and lower mortality rates (Hayman et al. 2016).

- **Altered wildfire regimes** due to climate-driven changes in fuel and fire behavior are likely to impact northern California bats, though there is relatively little research available on the topic. Existing research suggests that heat and smoke during fires can disturb roosting bats, and intense fires can cause injury or mortality in young bats that are still incapable of flight (Carter et al. 2002; Perry 2012). Most studies suggest that fire has an overall neutral or positive effect on bats, likely by maintaining more open forest conditions (Boyles & Aubrey 2006; Perry 2012; Buchalski et al. 2013). Higher-intensity fires leading to overstory tree mortality can create snags used for roosting (Carter et al. 2002; Boyles & Aubrey 2006; Perry 2012; Buchalski et al. 2013), while post-fire nutrient pulses can increase insect prey production (Malison & Baxter 2010). Additionally, the extent of high-severity fire appears to have little or no impact on foraging site selection at the landscape scale (Buchalski et al. 2013), and species that are adapted to foraging in open habitats and forest edges are positively associated with areas of higher fire frequency and burn severity (Buchalski et al. 2013; Blakey et al. 2019). Thus, climate-driven changes in wildfire regimes could potentially shift dominance towards open-adapted species and those that benefit from post-fire snags and insect prey (Blakey et al. 2019).

Dependency on habitat and/or other factors

Bats are highly dependent on the quantity and quality of their insect prey forage species and on particular habitat elements for resting, raising young, torpor, and hibernation (Kunz & Fenton 2005). Most species of bats roost in rock crevices, tree bark, or snags; some use caves or tree cavities (e.g., Townsend's big-eared bat; Fellers & Pierson 2002; Mazurek 2004), and two species roost in foliage (Johnston et al. 2004). A few species use man-made structures such as bridges, buildings, old mines, towers, and tunnels (Johnston et al. 2004).

Non-climate stressors

Non-climate stressors that contribute to the disturbance or loss of roosting and foraging areas or lead to direct mortality may exacerbate the effects of climate-driven changes.

- **Development** has resulted in fewer trees and more open areas, reducing forage opportunities and leaving bats susceptible to predation (Fellers & Pierson 2002; Fellers & Halstead 2015). The continued expansion of the wildland-urban interface (WUI), in particular, has isolated forage and roost habitat (Johnston et al. 2004). Longer distances to foraging areas increases energetic costs, and if travel costs exceed the benefits of the roost, local extirpation may result (Johnston et al. 2004).
- **Roads and highways** degrade habitat and affect nearby prey availability by creating a physical barrier, as well as by generating excessive light and noise, variable wind speeds, and temperature fluctuations (Berthinussen & Altringham 2012), resulting in reduced bat activity (Kitzes & Merenlender 2014).
- **Logging** in the mid-1900s removed old growth redwoods and Douglas fir that served as roosting habitat for bats such as *C. townsendii* (Fellers & Pierson 2002).
- **Wind turbines** cause direct bat mortality, and globally are among the leading causes of reported mass mortality events in bats (O'Shea et al. 2016).
- **Contaminants** such as organochlorine pesticides have been implicated in bat population declines over the past several decades, although their use has declined since the implementation of restrictions in the 1970s (Bayat et al. 2014). However, residues still persist in the environment, and rising use of other organic chemicals such as brominated flame retardants pose additional risks for bats. These contaminants can cause mortality in individuals

directly exposed to high concentrations or, indirectly, by ingesting contaminated prey. Low levels of many contaminants can also build up in bat tissues, causing sub-lethal physiological and neurological effects that can include immune suppression, reproductive failure, and behavioral changes that may impact survival (Bayat et al. 2014).

Adaptive Capacity

Species extent, status, connectivity, and dispersal ability

Many bat species, including those found in northern California, have experienced severe population declines and extirpation from large portions of their range, primarily due to habitat loss (Jones et al. 2009). While population declines are most common in species that are already rare or have small range sizes (Sherwin et al. 2013), they have also been observed in species that remain widespread. These include the little brown bat, which is heavily impacted by white-nose syndrome in the eastern U.S. (Lorch et al. 2016).

Bats have a high dispersal ability, and their mobility has contributed to their vast diversity and widespread distribution (Kunz & Fenton 2005; Sherwin et al. 2013).

Interspecific/life history diversity

Species that have a high fidelity to roost sites regardless of temperature (e.g., fringed myotis) may be more vulnerable to declines in reproductive output during dry years compared to species that exhibit greater flexibility (Adams & Hayes 2008; Adams 2010). By contrast, species that utilize a variety of roost sites, lack colony formation, and have low site fidelity may be better able to accommodate increasingly variable climate conditions without experiencing significant population declines (Adams 2018).

Resistance and recovery

Although bats are unusually long-lived compared to other mammals of similar size (Wilkinson & South 2002), they have low reproductive rates and often produce only 1–2 young per year (Becker et al. 2013). As a result, population dynamics are largely driven by adult mortality and their low annual reproductive output limits the ability of bat populations to recover from disturbance events (Jones et al. 2009; Adams 2018).

Management potential

Restoring the role of fire as a natural process in fire-adapted forests is considered a critical management strategy for cavity-nesting bats under changing climate conditions, both to generally increase roosting and foraging habitat conditions and to mitigate the risk of increasingly extreme wildfires on bat populations (Buchalski et al. 2013).

Monitoring efforts also suggest that protection of known bat maternity roosts and hibernaculum may increase population stability and even support recovery in species that are sensitive to disturbances such as the Townsend's big-eared bat (Weller et al. 2014; Fellers & Halstead 2015). However, increased long-term monitoring is necessary to better understand both current population trends and how future climate changes may impact northern California bats (Weller et al. 2014).

Recommended Citation

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Further information on the Northern California Climate Adaptation Project is available on the project website (https://tinyurl.com/NorCalAdaptation).

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