



## Sierra Nevada Individual Species Vulnerability Assessment Briefing: Woodrats

*Neotoma macrotis*; *Neotoma fuscipes*

### Background and Key Terminology

This document summarizes the primary factors that influence the vulnerability of a focal resource to climate change over the next century. In this context, vulnerability is a function of the sensitivity of the resource to climate change, its anticipated exposure to those changes, and its capacity to adapt to changes. Specifically, sensitivity is defined as a measure of whether and how a resource is likely to be affected by a given change in climate, or factors driven by climate; exposure is defined as the degree of change in climate or climate-driven factors a resource is likely to experience; and adaptive capacity is defined as the ability of a resource to accommodate or cope with climate change impacts with minimal disruption (Glick et al. 2011). The purpose of this assessment is to inform forest planning by government, non-profit, and private sector partners in the Sierra Nevada region as they work to integrate climate change into their planning documents.

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### Executive Summary

The overall vulnerability of both the big-eared and dusky-footed woodrat is ranked moderate, due to moderate-high sensitivity to climate and non-climate stressors, moderate adaptive capacity, and moderate exposure.

Big-eared and dusky-footed (*Neotoma macrotis* and *N. fuscipes*) woodrats are sensitive to climate-driven changes such as:

- increased temperature,
- decreased water availability, and
- altered wildfire regimes.

*Neotoma* woodrats rely on available drinking water, as well as the indirect impacts of precipitation on macrohabitat and food resources. Increased fire frequency may reduce understory cover and remove woody material for woodrat houses, and facilitate conversion to grassland annual habitat unsuitable for *Neotoma* woodrats.

Big-eared and dusky-footed woodrats (*Neotoma* spp.) are sensitive to non-climate stressors including:

- loss of habitat (e.g. non-native annual grass invasion).

Habitat loss and conversion to non-native annual grasslands reduces availability of high shrub cover and well-developed understories preferred by *Neotoma* woodrats. Introduction of non-native grasses contributes to increased fire frequency, and may exacerbate climate-driven conversion from chaparral to annual grassland. The capacity of *Neotoma* woodrats to adapt to climate change may be facilitated by generalist food and habitat requirements, as well as moderate to high genetic diversity in California.



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## Sensitivity & Exposure

### Sensitivity to climate and climate-driven changes

Big-eared and dusky-footed woodrats are sensitive to decreased precipitation and snowpack, and increases in temperature. Drinking water is required by big-eared (Lee 1963 cited in Carraway and Verts 1991) and probably dusky-footed woodrats, and as aridity increases big-eared (Spevak 1983 cited in Carraway and Verts 1991) and dusky-footed woodrats (Gillespie et al. 2008) population densities decrease significantly. Precipitation is also thought to be important for small mammal population dynamics through its effect on food resources (Meserve et al. 2001 cited in Lawson 2011), although woodrat populations in southern coastal California did not show a response to extreme precipitation associated with El Niño Southern Oscillation (ENSO) (Braswell 2007 cited in Lawson 2011). In the absence of a persisting blanket of snow, occasional severe weather, such as freezes in the wake of heavy rainfall, may cause large mortality events in dusky-footed woodrats (Murray and Barnes 1969), suggesting that reductions in snowpack volume and increases in rain:snow ratio may negatively impact *Neotoma* woodrat populations.

The impacts of altered fire regimes on *Neotoma* may be system-dependent. *Neotoma* woodrats occur in communities that are fire-adapted and experience relatively frequent fire. In chaparral communities, many shrubs are adapted to sprout or establish shortly after fire, however, increases in fire frequency intervals (e.g. <10 years) (Keeley 1995) are likely to be detrimental to *Neotoma* because of potential conversion to non-native annual grasslands (Bolger et al. 1997). Densities of both *Neotoma* woodrat species were highest where shrub cover is high (Vestal 1938, Linsdale and Tevis 1956, and Biswell 1989 cited in Lee and Tietje 2005) and understories were well-developed (Murray and Barnes 1969; Carraway and Verts 1991; Haynie et al. 2007; Innes et al. 2007), and lowest in open areas (Carraway and Verts 1991). In oak woodland habitat, low- to moderate-severity fire may reduce habitat suitability for dusky-footed woodrats in the short term by reducing understory cover, destroying woodrat houses, removing woody debris used to build houses (Lee and Tietje 2005), and causing direct mortality. Conversely, long periods without fire in mixed conifer forests may also result in a reduction of understory habitat suitable to dusky-footed woodrats due to decreased understory shrub density and diversity, and less favorable conditions for California black oaks (Chang et al. 1996 cited in Innes et al. 2007).

### Future climate exposure



Important climate and climate-driven factors to consider for *Neotoma* include increases in temperature, decreased precipitation, and altered wildfire regimes. Projections conflict on the future distribution of suitable habitats. While some models predict an increase in the distribution of chaparral, oak, and pine in northern California by 2070 (PRBO Conservation Science<sup>1</sup> et al. 2011), others predict the loss of virtually all suitable habitat for big-eared woodrats, with negligible amounts of emergent suitable habitat (Lawson 2011).

**Temperature:** Over the next century, annual temperatures in the Sierra Nevada are expected to rise between 2.4-3.4°C varying by season, geographic region, and elevation (Das et al. 2011; Geos Institute 2013). On average, summer temperatures are expected to rise more than winter temperatures throughout the Sierra Nevada region (Hayhoe et al. 2004; Cayan et al. 2008), with changes of least magnitude during both seasons anticipated in the central bioregion (Geos Institute 2013). Associated with rising temperatures will be an increase in potential evaporation (Seager et al. 2007).

**Precipitation and snow volume:** Precipitation has increased slightly (~2%) in the Sierra Nevada over the past 30 years compared with a mid-twentieth century baseline (1951-1980) (Flint et al. 2013). Projections for future precipitation in the Sierra Nevada vary among models; in general, annual precipitation is projected to exhibit only modest changes by the end of the century (Hayhoe et al. 2004; Dettinger 2005; Maurer 2007; Cayan et al. 2008), with decreases in summer and fall (Geos Institute 2013). Frequency of extreme precipitation, however, is expected to increase in the Sierra Nevada between 18-55% by the end of the century (Das et al. 2011). Despite modest projected changes in overall precipitation, models of the Sierra Nevada region largely project decreasing snowpack and earlier timing of runoff (Miller et al. 2003; Dettinger et al. 2004b; Hayhoe et al. 2004; Knowles and Cayan 2004; Maurer 2007; Maurer et al. 2007; Young et al. 2009), as a consequence of early snowmelt events and a greater percentage of precipitation falling as rain rather than snow (Dettinger et al. 2004a, 2004 b; Young et al. 2009; Null et al. 2010). Snow provides an important contribution to spring and summer soil moisture in the western U.S. (Sheffield et al. 2004), and earlier snowmelt can lead to an earlier, longer dry season (Westerling et al. 2006).

**Wildfire:** Both the frequency and annual area burned by wildfires in the western U.S. have increased strongly over the last several decades (Westerling et al. 2006). Fire severity in the Sierra Nevada also rose from 17% to 34% high-severity (i.e. stand replacing) fire, especially in middle elevation conifer forests (Miller et al. 2009). In the Sierra Nevada, increases in large fire extent have been correlated with increasing temperatures and earlier snowmelt (Westerling and Bryant 2006), as well as current year drought combined with antecedent wet years (Taylor and Beaty 2005). Occurrence of large fire and total area burned in California are predicted to continue increasing over the next century, with total area burned increasing by up to 74% by 2085 (Westerling et al. 2011). The area burned by wildfire in the Sierra Nevada is projected to increase between 35-169% by the end of the century, varying by bioregion, with the greatest

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<sup>1</sup> PRBO Conservation Science now called 'Point Blue'



increases projected at mid-elevation sites along the west side of the range (Westerling et al. 2011; Geos Institute 2013).

More information on downscaled projected climate changes for the Sierra Nevada region is available in a separate report entitled *Future Climate, Wildfire, Hydrology, and Vegetation Projections for the Sierra Nevada, California: A climate change synthesis in support of the Vulnerability Assessment/Adaptation Strategy process* (Geos Institute 2013). Additional material on climate trends for the system may be found through the TACCIMO website (<http://www.sgcp.ncsu.edu:8090/>). Downscaled climate projections available through the Data Basin website (<http://databasin.org/galleries/602b58f9bbd44dff487a04a1c5c0f52>).

### Sensitivity to non-climate stressors

Loss of habitat and invasion by non-native annual species pose threats to *Neotoma* populations, particularly in sage-scrub and chaparral systems (Bolger et al. 1997; Haynie et al. 2007). Both grazing and historic use of non-native annuals for post-fire rehabilitation in chaparral can introduce non-native invasive grasses, which contribute to greater fire frequency (Keeley 1995), exacerbating the impacts of climate-driven changes in fire regimes. Increased fire frequency can destroy woodrat homes and result in type-conversion to non-native invasive grassland.

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### Adaptive Capacity

The capacity of *Neotoma* woodrats to adapt to climate change may be facilitated by generalist food and habitat requirements, as well as moderate to high genetic diversity in California (Haynie et al. 2007). Prehistoric midden data for congeners also suggests that *Neotoma* woodrats have a strong capacity to adapt to changes in climate (Smith and Betancourt 2003 cited in Lawson 2011). *Neotoma* woodrats have a diet consisting of seeds, stems, and leaves of a variety of plants, and they occupy relatively dense chaparral, broad-leaf woodland, riparian thickets, or mixed conifer forest (Carraway and Verts 1991; Innes et al. 2007). East of the Cascade divide, dusky-footed woodrats consistently utilize juniper trees for lodging and food (Murray and Barnes 1969), and in mixed conifer forests dusky-footed woodrats displays strong associations with California black oak (Innes et al. 2007). Management techniques that promote growth and retention of large California black oaks in mixed conifer systems may benefit dusky-footed woodrats (Innes et al. 2007).

However, the adaptive capacity of *Neotoma* woodrats may be hindered by their limited dispersal capacity. For example, home-range sizes for adult dusky-footed woodrats vary widely (0.2-5.9 ha) (0.5-14.6 ac) (Innes et al. 2009), and some studies indicate good dispersal ability (Smith 1965 cited in Lawson 2011). However, dusky-footed woodrat females are largely philopatric and do not disperse from natal areas (Innes et al. 2012). Although female big-eared woodrats do not appear to display the same high levels of philopatry (Matocq and Lacey 2004 cited in Lawson 2011; Haynie et al. 2007), essentially no elevational shift was recorded for this species during the previous 100 years of climate warming in Yosemite National Park (Moritz et al. 2008). Limited dispersal may hinder the *Neotoma* woodrats' ability to adapt to climate-driven changes and follow vegetative shifts along elevational gradients. Dispersal of both



species may be further limited by the presence of roads, water bodies, and open spaces (Carraway and Verts 1991; Bolger 1997).

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