



Sierra Nevada Ecosystem Vulnerability Assessment Briefing: Chaparral

CWHR Types¹: **MCP:** *Ceanothus* spp., manzanita (*Arctostaphylos* spp.), bitter cherry (*Prunus emarginata*); **MCH:** Scrub oak (*Quercus* spp.), *Ceanothus* spp., manzanita (*Arctostaphylos* spp.); **CRC:** Chamise (*Adenostoma fasciculatum*), *Ceanothus* spp.

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.

Executive Summary

The overall vulnerability of the chaparral system is ranked moderate, due to moderate sensitivity to climate and non-climate stressors, moderate adaptive capacity, and moderate exposure.

The chaparral system is sensitive to climate and climate-driven changes such as:

- altered fire regimes,
- increased climatic water deficit, and
- increased temperature (benefit).

Chaparral systems rely on disturbance regimes, and may gain comparative benefit from increased fire and climatic water deficit in the region, as well as warming temperatures. However, component species within the systems are differentially sensitive to water availability, and some may decline or become restricted to ephemeral washes.

The chaparral system is sensitive to non-climate stressors including:

- habitat conversion (e.g. logging and residential development),
- invasive alien species, and
- disease.

These non-climate stressors can increase fragmentation, limiting the capacity of chaparral to disperse, and can increase competition for water, compounding the effects of climate-driven

¹ Following the California Wildlife Habitat Relationship (CWHR) System found at http://www.dfg.ca.gov/biogeodata/cwhr/wildlife_habitats.asp

changes, such as climatic water deficit. The sensitivity of the chaparral system to climate change is tempered largely by drought and fire tolerance and its extensive distribution.

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Sensitivity & Exposure

Sensitivity to climate and climate-driven changes

Chaparral systems are sensitive to several climate and climate-driven changes, including changes in fire regimes, water-deficit and temperature; however, component species display considerable variation in their climate-related sensitivities. The chaparral system relies on disturbance regimes (Long et al. 2013) such as fire, which typically occurs at intervals of 20-50 years (Keeley 1995). Chaparral flora include taxa that are both resilient to fire but have no specialized adaptations to fire, as well as taxa that are resilient to fire and that have specialized adaptations to coincide seedling recruitment with post-fire conditions (Keeley 1991). Chaparral shrubs may regenerate after fire by seedling recruitment, resprouting, or by a combination of methods (Keeley et al. 2005; Ramirez et al. 2012). Seedling recruitment for facultative- and obligate-seeders is facilitated by fire (Keeley 1991; Keeley et al. 2005; Ramirez et al. 2012). Evidence suggests that in some cases the absence of fire facilitates conifer encroachment (Nagel and Taylor 2005; Beaty and Taylor 2008) as well as the deterioration of soil-stored seeds of facultative- and obligate-seeding species (Keeley and Keeley 1977, and Zammit and Zedler 1984, 1994 cited in Keeley et al. 2005). However, chaparral stands can persist at least 90 years without fire, with little evidence of seed deterioration (Keeley et al. 2005). Further, fire-free periods are required for obligate-resprouters to recruit seedlings (Keeley 1992b cited in Keeley et al. 2005). Conversely, very short fire intervals (<10 years) may cause type conversion to grassland annuals (Keeley 1995), resulting in loss of primarily obligate seeders, and survival of sprouters and annual grasses (Keeley 1995; Keeley and Brennan 2012). Increased severity fires have negative impacts on resprouting success (Rundel et al. 1987, Moreno and Oechel 1991, and Borchert and Odion 1995 cited in Keeley et al. 2005).

Chaparral species are also differentially sensitive to water availability. Dry conditions may select for facultative sprouters, while comparatively wet conditions may be favored by non-sprouters and post-fire seeding species (Ramirez et al. 2012), as well as species that require fire-free periods for recruitment, as germination typically occurs within several weeks of the first fall or winter rains (Keeley 1991). A reduction in soil moisture and predicted increases in climatic water deficit may result in changes in species composition and range shifts of species dependent on more mesic conditions. Certain species, such as manzanita may become limited to ephemeral washes during future drought conditions (Gitlin et al. 2006). However, the

distributional limits of some chaparral species are set by sensitivity to frost, especially as it affects seedlings (Pratt et al. 2005). Reduced exposure to freezing events at upper elevational limits along Sierra Nevada foothills may facilitate elevational expansion of chaparral range (Pratt et al. 2005). Distributional shifts of chaparral into new areas are likely to occur as temperatures warm (Pratt et al. 2005) and following fires (Keeley 1991).

Future climate exposure

Important climate and climate-driven factors to consider for the chaparral system include increases in temperature, decreases in precipitation, climatic water deficit, and fire. The forecast for chaparral distribution in response to climate change is not uniform throughout California, some models predict increases in the distribution of chaparral in northern California and decreases in chaparral in central western California by 2070 (PRBO Conservation Science² et al. 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).

Climatic water deficit: Climatic water deficit, which combines the effects of temperature and rainfall to estimate site-specific soil moisture, is a function of actual evapotranspiration and

² PRBO Conservation Science now called "Point Blue".

potential evapotranspiration. Increases in potential evapotranspiration will likely be the dominant influence in future hydrologic cycles in the Sierra Nevada, decreasing runoff even under forecasts of increased precipitation, and driving increased climatic water deficits (Thorne et al. 2012). In the Sierra Nevada, climatic water deficit has increased slightly (~4%) in the past 30 years compared with the 1951-1980 baseline (Flint et al. 2013). Future downscaled water deficit modeling using the Basin Characterization Model predicts increased water deficits (i.e., decreased soil moisture) by up to 44%, with the greatest increases in the northern Sierra Nevada (Thorne et al. 2012; Flint et al. 2013; Geos Institute 2013).

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 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

Chaparral systems also exhibit sensitivity to various non-climate stressors, including habitat alteration (e.g. land development), invasive species and disease that may compound the impacts of climate change. Historic use of non-native annuals for post-fire rehabilitation has been associated with increased fires, as these species can form a more continuous cover and dry out sooner in spring than natives (Keeley 1995). In turn, short-interval fires have been shown highly effective in converting chaparral to grasslands dominated by alien annuals (Sampson 1944, Burcham 1955 cited in Keeley and Brennan 2012). Conversion of California shrublands to invasive annual grasslands may also be facilitated by livestock grazing and trampling disturbance (Keeley and Brennan 2012).

In addition, several component species (including manzanita, madrone, buckeye, and toyon) within the chaparral system are susceptible to the sudden oak death (i.e. fungus *Phytophthora*). Moisture is essential for survival and sporulation of *P. ramorum*, and the duration, frequency,

and timing of rain events during winter and spring play a key role in inoculum production. Increases in winter precipitation may produce optimal conditions for the pathogen in some areas, resulting in increased rates of infection in Washington, Oregon and California (Venette and Cohen 2006, Venette 2009 cited in Sturrock et al. 2011).

Adaptive Capacity

The adaptive capacity of the chaparral system is facilitated largely by its general tolerance of drought and fire, as well as its extensive spatial distribution. Adaptations supporting post-disturbance recovery vary among chaparral species, and include fire dependence, extensive seed dormancy and long lifespan of obligate reproters (i.e. species that survive fire and re-establish by resprouting), as well as high fecundity and tolerance of drought and soil infertility by obligate seeders (i.e. species that are killed by fire and recruit from soil seed banks) (see Anacker et al. 2011 for a list of relevant primary research). Obligate- and facultative-seeders are generally dependent upon fire for seedling recruitment (Keeley 1991; Keeley et al. 2005) suggesting that increased fire frequency and area may facilitate population expansion for some chaparral species when seed banks are present. However, chaparral is also resilient to long (>80 year) fire-free periods, and soil-stored seeds display little deterioration up to approximately 80 years of age (Keeley et al. 2005). Species that require fire-free periods for recruitment are dispersed largely by a range of mechanisms, including wind and bird dispersers (Keeley 1991), and chaparral is among the most extensive vegetation types in the Sierra Nevada, covering 5% of the state (California Legislature 1987). Wide distribution and broad dispersal mechanisms may further support the capacity of the system to capitalize on changing climate conditions.

However, resprouting success is negatively correlated with fire severity (Rundel et al. 1987, Moreno and Oechel 1991, and Borchert and Odion 1995 cited in Keeley et al. 2005), suggesting that projected increases in fire severity may prove detrimental to chaparral persistence. Chaparral is also considerably fragmented, and habitat conversion, particularly in the central Sierra Nevada, may contribute to seed bank isolation and limit dispersal potential, exacerbating the impacts of severe fire.

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