Southern California Oak Woodland Habitats

Climate Change Vulnerability Assessment Summary

An Important Note About this Document: *This document represents an initial evaluation of vulnerability for oak woodland habitats based on expert input and existing information. Specifically, the information presented below comprises habitat expert vulnerability assessment survey results and comments, peer-review comments and revisions, and relevant references from the literature. The aim of this document is to expand understanding of habitat vulnerability to changing climate conditions, and to provide a foundation for developing appropriate adaptation responses.*

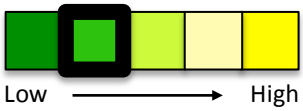
Photo by Noah Elhardt (Public Domain)

Habitat Description

Southern California contains primarily coastal oak woodlands and montane hardwoods, with coast live oak dominating the former,[1] and black oak and canyon live oak dominating the latter.[2] Many other species can co-occur with these dominants,[1-4] and many oak species occur as sub-dominants in other habitat types.[6] Northern parts of the study area also contain blue oak and valley oak woodlands, which reach the southern end of their distribution in this region.[3,4,7,8] As dominant canopy species, oaks create favorable microclimates for diverse understory vegetation and provide critical wildlife habitat.[9-11]

Habitat Vulnerability

Low-Moderate Vulnerability



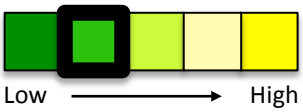
The relative vulnerability of oak woodland habitats in southern California was evaluated to be low-moderate by habitat experts due to low-moderate sensitivity to climate and non-climate stressors, low-moderate exposure to projected future climate changes, and moderate adaptive capacity. Shifts in precipitation and soil moisture are likely to affect oak woodland distribution, composition, growth, and recruitment, and impacts may be compounded by shifts in temperature and drought frequency and intensity. Although adapted to wildfire, shifts in wildfire frequency and intensity may affect oak recruitment and survival. Invasive plant species compete with oak seedlings for soil moisture, while invasive insects (e.g., gold-spotted oak borer, polyphagous shot hole borer) are contributing to high oak mortality within the study region, and may expand with climate change. Land-use conversion has altered the extent and continuity of oak woodland habitat, and continues to threaten this system by facilitating invasive species introductions, increasing wildfire ignition risk, and eliminating potential refugia. Oak woodland habitat has been altered and fragmented as a result of agriculture and development, and habitat structure is being affected by exotic annual grass invasions. Oaks are long-lived species with variable recruitment and limited migration potential, making it difficult for these species to keep pace with projected climate changes. Canopy diversity is fairly low, and as keystone species, loss of oak canopy species would eliminate or cause severe changes in

Copyright EcoAdapt 2017.

oak woodland habitat. Oak woodland habitats provide a variety of ecosystem services including biodiversity, recreation, and carbon sequestration.

Sensitivity

Low-Moderate Sensitivity



Moderate Confidence

Oak woodland habitats are sensitive to several climate drivers, including precipitation, soil moisture, air temperature, and drought. These drivers largely influence oak distribution at landscape and local scales, vegetation composition,[12-14] recruitment,[15,16] and survival.[17,18] Young oaks have a narrower climatic envelope than adults; they are more sensitive to warmer temperatures,[13] moisture stress[19], and fire than mature trees.[18,20] Wildfire resets oak succession,[8,21,22] while insects and disease can cause significant oak mortality.[23-25]

Habitat sensitivity factors and impacts*

CLIMATIC DRIVERS Low-Moderate Sensitivity High Confidence	
Precipitation & soil moisture	Moisture availability (influenced by rainfall, competition, soil texture, and evaporative stress[26-28]) drives oak survival, reproduction, recruitment, and habitat distribution. Precipitation and soil moisture shifts may result in: • Distribution shifts and/or shifts in dominant oak canopy species[12] • Increased oak mortality and habitat contraction with drier conditions[17,18] • Continued variability in acorn production;[8, 15,16] production thought to be positively correlated with precipitation 1-2 years prior to acorn crop[16] • Altered acorn germination; germination and seedling emergence decline in dry years,[18,27,29,30] although shade from nurse plants and oak canopies can create favorable microsites[27,31] • Altered disease vulnerability[32]
Air temperature	Air temperatures affect oak woodland distribution and recruitment. Increased air temperature may cause: • Continued variability in acorn production; [8,15,16] warmer April temperatures thought to favor pollination and fertilization[16] • Reduced acorn germination and seedling survival • Increased vulnerability to insects[23]
Drought	Oaks are resilient to and accommodate seasonal short-term drought,[9,18,33] but sensitivity to prolonged drought varies by species and age class.[9,19,33-35] Increased drought may cause: • Increased oak mortality and dieback
DISTURBANCE REGIMES Low-Moderate Sensitivity Low Confidence	
Wildfire	Wildfire influences oak woodland species composition, form, and density.[8] Many oak species are resilient to periodic burning[21] due to thick bark and the ability to re-sprout post-fire,[20] but fire sensitivity and post-fire recovery varies

* Factors presented are those ranked highest by habitat experts. A full list of evaluated factors can be found in the Oak Woodlands Climate Change Vulnerability Assessment Synthesis.

† Relevant references for regional climate projections can be found in the Southern California Climate Overview

Copyright EcoAdapt 2017.

	by species, tree age and size,[8,18,20] and fire seasonality.[18,20,22,36] Shifts in fire regimes may cause: • Reduced sapling recruitment[37] and tree mast • Increased mature oak damage and mortality[9,18,36,38] • Reduction of favorable germination sites via topsoil[21] and leaf litter loss[18] • Potential conversion to more fire-tolerant vegetation[8]
Insects	The introduced gold-spotted oak borer has caused significant mortality of coast live oak, canyon live oak, and black oak in southern California. Interior live oaks and Englemann oaks may also be vulnerable.[23-25] This pest may expand northward, as much of the state is projected to be climatically suitable in the future.[23] Coast live oaks, canyon live oaks, and valley oak may also be vulnerable to Fusarium dieback, which is associated with the polyphagous shot hole borer and its affiliated fungus.[39]
Disease	Vulnerability to sudden oak death may change with shifting precipitation patterns,[32] although incidence is not currently high in southern California.[25]
NON-CLIMATE STRESSORS Moderate Sensitivity & Exposure High Confidence	
Invasive & problematic species	Non-native species, particularly *Bromus* spp. and other annual grasses, can inhibit oak germination, seedling growth, and seedling survival by competing for soil moisture and other resources (e.g., space, nutrients, light).[18,26,40,41] Invasive grasses also exacerbate shifting fire regimes.[18]
Land-use conversion	Oak woodland habitat development rates in southern California are the highest in the entire state.[42] Development and agricultural conversion threaten oak woodland extent and continuity, particularly low elevation woodlands[6,43] adjacent to existing development. Habitat fragmentation affects pollen movement and gene flow, potentially increasing reproductive isolation and altering recruitment.[6,44] Land-use conversion can also reduce climate microrefugia, alter water availability,[17,45] create edge effects,[6] or alter ignition rates, exacerbating fire regime shifts.[38,46]

Exposure[†]

Under future climate conditions, oak woodland habitats are likely to be exposed to decreased soil moisture, increased air temperature and extreme high temperature events, precipitation changes, enhanced drought conditions, and increased wildfire. Many oak woodland habitats are projected to experience range contractions and distribution shifts in response to climate change and human impacts. By mid-century, coast live oak and Englemann oak are projected to have only 28% and 46% of current distribution within thermal refugia, while blue oak, black oak, and valley oak are projected to have only 10%, 48% and 13% of current habitat in refugia over the same time period.[47] Many of these species are projected experience range

[†] Relevant references for regional climate projections can be found in the Southern California Climate Overview (http://ecoadapt.org/programs/adaptation-consultations/socal).

Copyright EcoAdapt 2017.

Literature Cited

[1] California Wildlife Habitat Relationship System (CWHRS). (2015a). Coastal oak woodland. Accessed Nov 15, 2015.

[2] California Wildlife Habitat Relationship System (CWHRS). (2015b). Montane hardwood. Accessed November 15, 2015. Retrieved from https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=67338&inline=1

[3] California Wildlife Habitat Relationship System (CWHRS). (2015c). Blue oak woodland. Accessed November 15, 2015. Retrieved from https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=67340&inline=1

[4] California Wildlife Habitat Relationship System (CWHRS). (2015d). Valley oak woodland. Accessed November 15, 2015. Retrieved from https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=67342&inline=1

[5] Bartolome, J. W. (1987). California annual grassland and oak savannah. *Rangelands, 9*(3), 122-125.

[6] Los Angeles County Oak Woodlands Habitat Conservation Strategic Alliance (Los Angeles County). (2011). *Los Angeles County Oak Woodlands Conservation Management Plan*. Los Angeles County Oak Woodlands Habitat Conservation Strategic Alliance. Retrieved from http://planning.lacounty.gov/oakwoodlands/documents

[7] Hoagland, S., Krieger, A., Moy, S., & Shepard, A. (2011). *Ecology and management of oak woodlands on Tejon Ranch: Recommendations for conserving a valuable California ecosystem* (Master of Environmental Science and Management). Santa Barbara, CA: University of California, Santa Barbara. Retrieved from http://www.bren.ucsb.edu/research/documents/tejonoaks_report.pdf

[8] Plumb, T. R., & McDonald, P. M. (1981). *Oak management in California*. (Gen. Tech. Rep. GTR-PSW-54). Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. Retrieved from http://www.fs.fed.us/psw/publications/documents/psw_gtr054/psw_gtr054.pdf

[9] Howard, J. L. (1992). Quercus lobata. *Fire Effects Information System [Online].* Retrieved from http://www.fs.fed.us/database/feis/plants/tree/quelob/all.html

[10] Tietje, W., Purcell, K., & Drill, S. (2005). Oak woodlands as wildlife habitat. In G. A. Guisti, D. D. McCreary, & R. B. Standiford (Eds.), *A planner's guide for oak woodlands* (2nd ed.): University of California, Division of Agriculture and Natural Resources, Publication 3491.

[11] Verner, J. (1987). The importance of hardwood habitats for wildlife in California. In T.R. Plumb & N.H. Pillsbury (Eds.), *Proceedings of the symposium on multiple-use management of California's hardwood resources; November 12-14, 1986; San Luis Obispo, California* (pp. 162). (Gen. Tech. Rep. PSW-100). Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Retrieved from http://www.fs.fed.us/psw/publications/documents/psw_gtr100/psw_gtr100_004.pdf

[12] Kueppers, L. M., Snyder, M. A., Sloan, L. C., Zavaleta, E. S., & Fulfrost, B. (2005). Modeled regional climate change and California endemic oak ranges. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(45), 16281-16286.

[13] McLaughlin, B. C., and Zavaleta, E. S. (2012). Predicting species responses to climate change: Demography and climate microrefugia in California valley oak (Quercus lobata). *Global Change Biology*, *18*(7), 2301-2312.

[14] Waddell, K. L., & Barrett, T. M. (2005). *Oak woodlands and other hardwood forests of California, 1990s*. (Resource Bulletin PNW-RB-245). Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station. Retrieved from http://www.fs.fed.us/pnw/pubs/pnw_rb245.pdf

[15] Koenig, W. D., Mumme, R. L., Carmen, W. J., & Stanback, M. T. (1994). Acorn production by oaks in central coastal California: Variation within and among years. *Ecology, 75*(1), 99-109.

[16] Koenig, W. D., Knops, J. M., Carmen, W. J., Stanback, M. T., & Mumme, R. L. (1996). Acorn production by oaks in central coastal California: Influence of weather at three levels. *Canadian Journal of Forest Research, 26*(9), 1677-1683.

[17] Hayes, J. J., & Donnelly, S. (2014). A resilience-based approach to the conservation of valley oak in a southern California landscape. *Land, 3*(3), 834-849.

[18] Principe, Z.A. (2002). *Factors affecting Engelmann oak (Quercus engelmanni) regeneration.* (Master of Science). San Diego, CA: San Diego State University.

Copyright EcoAdapt 2017.

[19] Matzner, S. L., Rice, K. J., & Richards, J. H. (2003). Patterns of stomatal conductance among blue oak (Quercus douglasii) size classes and populations: Implications for seedling establishment. *Tree Physiology, 23*(11), 777-784.

[20] Plumb, T. R., & Gomez, A. P. (1983). *Five southern California oaks: Identification and postfire management*. (Gen. Tech. Rep. PSW-GTR-71). Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. Retrieved from http://www.fs.fed.us/psw/publications/documents/psw_gtr071/psw_gtr071a.pdf

[21] McCreary, D.D. (2004). Fire in California's oak woodlands. Browns Valley, CA: University of California Cooperative Extension. Retrieved from http://ucanr.edu/sites/oak_range/files/59574.pdf

[22] Lathrop, E. W., & Osborne, C. D. (1991). Influence of fire on oak seedlings and saplings in a southern oak woodland on the Santa Rosa Plateau Preserve, Riverside County, California. In R. B. Standiford (Ed.), *Proceedings of the symposium on oak woodlands and hardwood rangeland management; October 31-November 2, 1990: Davis, California* (pp. 366-370). (Gen. Tech. Rep. PSW-GTR-126). Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Retrieved from http://www.treesearch.fs.fed.us/pubs/28459

[23] Coleman, T. W., Jones, M. I., Smith, S. L., Venette, R. C., Flint, M. L., & Seybold, S. J. (2015). Goldspotted oak borer. *Forest Insect & Disease Leaflet 183*. USDA Forest Service. Retrieved from http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3833276.pdf

[24] Coleman, T. W., Grulke, N. E., Daly, M., Godinez, C., Schilling, S. L., Riggan, P. J., & Seybold, S. J. (2011). Coast live oak, Quercus agrifolia, susceptibility and response to goldspotted oak borer, Agrilus auroguttatus, injury in southern California. *Forest Ecology and Management, 261*(11), 1852-1865.

[25] Coleman, T. W., & Seybold, S. J. (2008). Previously unrecorded damage to oak, Quercus spp., in southern California by the goldspotted oak borer, Agrilus coxalis Waterhouse (Coleoptera: Buprestidae). *The Pan-Pacific Entomologist, 84*(4), 288-300.

[26] Plumb, T. R., & De Lasaux, M. D. (1997). An evaluation of coast live oak regeneration techniques. In N. H. Pillsbury, J. Verner, & W. D. Tietje (Tech. coord.), *Proceedings of the symposium on oak woodlands: ecology, management, and urban interface issues; March 19–22, 1996; San Luis Obispo, California.* (pp. 231-242). (Gen. Tech. Rep. PSW-GTR-160). Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Retrieved from http://www.fs.fed.us/psw/publications/documents/psw_gtr160/psw_gtr160_04b_plumb.pdf

[27] Plumb, T. R., & Hannah, B. (1991). Artificial regeneration of blue and coast live oaks in the central coast. In R. B. Standiford (Ed.), *Proceedings of the symposium on oak woodlands and hardwood rangeland management; October 31-November 2, 1990; Davis, California* (pp. 74-80). (Gen. Tech. Rep. PSW-GTR-126). Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Retrieved from http://www.treesearch.fs.fed.us/pubs/28401

[28] Plumb, T. R., & Kraus, K. (1991). Oak woodland artificial regeneration - correlating soil moisture to seedling survival. In R. B. Standiford (Ed.), *Proceedings of the symposium on oak woodlands and hardwood rangeland management; October 31-November 2, 1990; Davis, California.* (pp. 91-95). (Gen. Tech. Rep. PSW-GTR-126). Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Retrieved from http://www.treesearch.fs.fed.us/pubs/28404

[29] Tyler, C. M., Davis, F. W., & Mahall, B. E. (2008). The relative importance of factors affecting age-specific seedling survival of two co-occurring oak species in southern California. *Forest Ecology and Management, 255*(7), 3063-3074.

[30] Griffin, J. R. (1971). Oak regeneration in the upper Carmel Valley, California. *Ecology, 52*(5), 862-868.

[31] Tyler, C. M., Kuhn, B., & Davis, F. W. (2006). Demography and recruitment limitations of three oak species in California. *The Quarterly Review of Biology*, *81*(2), 127-152.

[32] Meentemeyer, R., Rizzo, D., Mark, W., & Lotz, E. (2004). Mapping the risk of establishment and spread of sudden oak death in California. *Forest Ecology and Management, 200*(1), 195-214.

Copyright EcoAdapt 2017.

[33] Steinberg, P. D. (2002). Quercus agrifolia. *Fire Effects Information System, [Online].* Retrieved from http://www.fs.fed.us/database/feis/plants/tree/queagr/all.html#27

[34] Principe, Z. (2015). Influence of fire on Engelmann oak survival – patterns following prescribed fires and wildfires. In R. B. Standiford & K. Purcell (Eds.), *Proceedings of the seventh California oak symposium: Managing oak woodlands in a dynamic world* (pp. 175–185). (Gen. Tech. Rep. PSW-GTR-251). Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Retrieved from http://www.treesearch.fs.fed.us/pubs/49983

[35] Callaway, R. M. (1990). Effects of soil water distribution on the lateral root development of three species of California oaks. *American Journal of Botany, 77*(11), 1469-1474.

[36] Paysen, T. E., & Narog, M. G. (1993). Tree mortality 6 years after burning a thinned Quercus chrysolepis stand. *Canadian Journal of Forest Research, 23*(10), 2236-2241.

[37] Swiecki, T. J., & Bernhardt, E. (1998). Understanding blue oak regeneration. *Fremontia, 26*(1), 19-26.

[38] Conlisk, E., Lawson, D., Syphard, A. D., Franklin, J., Flint, L., Flint, A., & Regan, H. M. (2012). The roles of dispersal, fecundity, and predation in the population persistence of an oak (Quercus engelmannii) under global change. *PloS ONE, 7*(5), e36391.

[39] Eskalen, A., Stouthamer, R., Lynch, S. C., Rugman-Jones, P. F., Twizeyimana, M., Gonzalez, A., & Thibault, T. (2013). Host range of Fusarium dieback and its ambrosia beetle (Coleoptera: Scolytinae) vector in southern California. *Plant Disease, 97*(7), 938-951.

[40] Danielsen, W. L., & Halvorson, K. C. (1991). Valley oak seedling growth associated with selected grass species. In R. B. Standiford (Ed.), *Proceedings of the symposium on oak woodlands and hardwood rangeland management; October 31-November 2, 1990: Davis, California* (pp. 9-13). (Gen. Tech. Rep. PSW-GTR-126). Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Retrieved from http://ftp.fs.fed.us/psw/publications/documents/psw_gtr126/psw_gtr126_01_danielsen.pdf

[41] Gordon, D. R., & Rice, K. J. (2000). Competitive suppression of Quercus douglasii (Fagaceae) seedling emergence and growth. *American Journal of Botany, 87*(7), 986-994.

[42] Gaman, T., & Firman, J. (2006). *Oaks 2040: The status and future of oaks in California*. Oakland, CA: California Oak Foundation. Retrieved from http://www.californiaoaks.org/ExtAssets/Oaks%202040%20Main%20Text1108.pdf

[43] Jimerson, T. M., & Carothers, S. K. (2002). Northwest California oak woodlands: Environment, species composition, and ecological status. In R. B. Standiford (Ed.), *Proceedings of the fifth symposium on oak woodlands: Oaks in California's challenging landscape* (pp. 705-717). (Gen. Tech. Rep. PSW-GTR-184). Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Retrieved from http://www.treesearch.fs.fed.us/pubs/26167

[44] Sork, V. L., Davis, F. W., Smouse, P. E., Apsit, V. J., Dyer, R. J., Fernandez-M, J., & Kuhn, B. (2002). Pollen movement in declining populations of California Valley oak, Quercus lobata: Where have all the fathers gone? *Molecular Ecology, 11*(9), 1657-1668.

[45] Garcia, S. L., Jensen, W. A., Weitkamp, W. H., & Tietje, W. D. (1991). Acorn yield during 1988 and 1989 on California's central coast. In R. B. Standiford (Ed.), *Proceedings of the symposium on oak woodlands and hardwood rangeland management; October 31-November 2, 1990: Davis, California* (pp. 161-163). (Gen. Tech. Rep. PSW-GTR-126). Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Retrieved from http://www.fs.fed.us/psw/publications/documents/psw_gtr126/psw_gtr126_02_garcia.pdf

[46] Syphard, A. D., Clarke, K. C., & Franklin, J. (2007). Simulating fire frequency and urban growth in southern California coastal shrublands, USA. *Landscape Ecology, 22*(3), 431-445.

[47] Principe, Z. A., MacKenzie, J. B., Cohen, B., Randall, J. M., Tippets, W., Smith, T., & Morrison, S. A. (2013). *50-year climate scenarios and plant species distribution forecasts for setting conservation priorities in Southwestern California*. San Francisco, CA: The Nature Conservancy of California. Retrieved from http://scienceforconservation.org/dl/SW_CA_Climate_Report_v1_Oct_2013.pdf

Copyright EcoAdapt 2017.

[48] Davis, F. W., Stoms, D. M., Hollander, A. D., Thomas, K. A., Stine, P. A., Odion, D., . . . Graae, J. (1998). *The California gap analysis project: Final report*. Santa Barbara, CA: University of California, Santa Barbara. Retrieved from http://www.biogeog.ucsb.edu/projects/gap/gap_rep.html

[49] Montalvo, A., Conard, S., Conkle, M., & Hodgskiss, P. (1997). Population structure, genetic diversity, and clone formation in Quercus chrysolepis (Fagaceae). *American Journal of Botany, 84*(11), 1553-1553.

[50] Sork, V. L., Davis, F. W., Westfall, R., Flint, A., Ikegami, M., Wang, H., & Grivet, D. (2010). Gene movement and genetic association with regional climate gradients in California valley oak (Quercus lobata Née) in the face of climate change. *Molecular Ecology, 19*(17), 3806-3823.

Copyright EcoAdapt 2017.