Conservation Gap Analysis of Native U.S. Oaks

Species profile: ***Quercus engelmannii***

Emily Beckman, Tom Gaman, Abby Meyer, Murphy Westwood

SPECIES OF CONSERVATION CONCERN

CALIFORNIA

Channel Island endemics:
Quercus pacifica, Quercus tomentella

Southern region:
Quercus cedrosensis, Quercus dumosa, ***Quercus engelmannii***

Northern region and / or broad distribution:
Quercus lobata, Quercus parvula, Quercus sadleriana

SOUTHWESTERN U.S.

Texas limited-range endemics
Quercus carmenensis, Quercus graciliformis, Quercus hinckleyi, Quercus robusta, Quercus tardifolia

Concentrated in Arizona:
Quercus ajoensis, Quercus palmeri, Quercus toumeyi

Broad distribution:
Quercus havardii, Quercus laceyi

SOUTHEASTERN U.S.

State endemics:
Quercus acerifolia, Quercus boyntonii

Concentrated in Florida:
Quercus chapmanii, Quercus inopina, Quercus pumila

Broad distribution:
Quercus arkansana, Quercus austrina, Quercus georgiana, Quercus oglethorpensis, Quercus similis

The Morton Arboretum®
BOTANIC GARDENS CONSERVATION INTERNATIONAL
FOREST SERVICE U.S. DEPARTMENT AGRICULTURE
FAUNA & FLORA INTERNATIONAL

Quercus engelmannii Greene

Synonyms: N/A **Common Names:** Engelmann oak, Mesa oak, Pasadena oak

Species profile co-author: **Tom Gaman,** East-West Forestry Associates, Inc. / California Wildlife Foundation
Contributors: **Jim Henrich,** Los Angeles County Arboretum & Botanic Garden; **Tim Thibault,** The Huntington

Suggested citation: Beckman, E., Gaman, T., Meyer, A., & Westwood, M. (2019). *Quercus engelmannii* Greene. In Beckman, E., Meyer, A., Man, G., Pivorunas, D., Denvir, A., Gill, D., Shaw, K., & Westwood, M. *Conservation Gap Analysis of Native U.S. Oaks* (pp. 104-109). Lisle, IL: The Morton Arboretum. Retrieved from https://www.mortonarb.org/files/species-profile-quercus-engelmanii.pdf

Frank McDonough

DISTRIBUTION AND ECOLOGY

Quercus engelmannii, or Engelmann oak, is sporadically distributed south from southern California, U.S., to northwestern Baja California, Mexico. It occurs in four California Floristic Provinces: South Coast, San Gabriel Mountains, Peninsular Ranges, and San Jacinto Mountains. A subpopulation is also present on Santa Catalina Island (T. Gaman pers. comm., 2018). Engelmann oak is commonly found growing in stands with Coast live oak. Suitable habitat for *Q. engelmannii* is restricted by adequate rainfall (at least 15 inches per year), rare instances of frost, and moderate summer temperatures. These landscapes include valley grassland, foothill woodlands above the dry coastal plain, and margins of chaparral. Gentle, southern facing slopes are a favorite habitat, with soil type ranging from deep loamy-clay to shallow, rocky soils.[1] *Quercus engelmannii* is characterized by an open structure, reaching five to 25 meters in height. It has dull blue-green leaves, which are oblong to obovate and evergreen.[2]

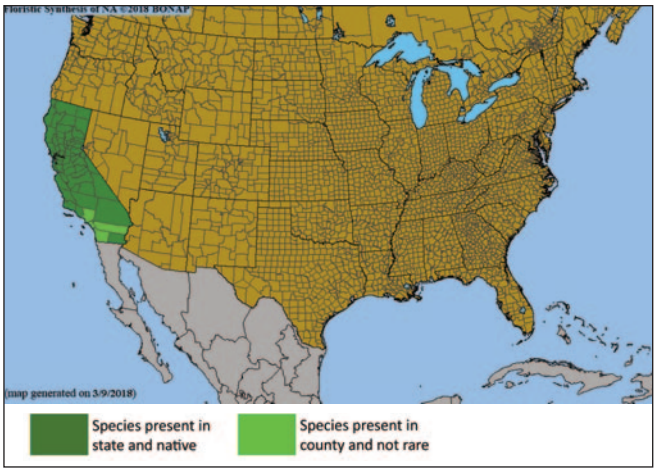


Figure 1. County-level distribution map for the U.S. distribution of *Quercus engelmannii*. Source: Biota of North America Program (BONAP).[3]

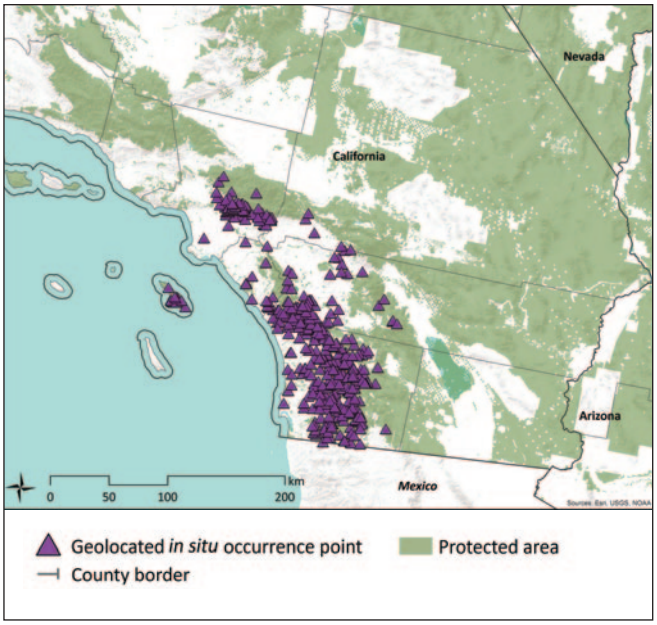


Figure 2. Documented *in situ* occurrence points for the U.S. distribution of *Quercus engelmannii*. Protected areas layer from U.S. Geological Survey Gap Analysis Program (GAP) 2016 Protected Areas Database of the U.S. (PAD-US).[4]

VULNERABILITY OF WILD POPULATIONS

Table 1. Scoring matrix identifying the most severe demographic issues affecting *Quercus engelmannii*. Cells are highlighted when the species meets the respective vulnerability threshold for each demographic indicator. Average vulnerability score is calculated using only those demographic indicators with sufficient data (i.e., excluding unknown indicators).

Demographic indicators	Level of vulnerability						
	Emergency Score = 40	**High** Score = 20	**Moderate** Score = 10	**Low** Score = 5	**None** Score = 0	**Unknown** No score	**Score**
Population size	< 50	< 250	< 2,500	< 10,000	> 10,000	Unknown	5
Range/endemism	Extremely small range or 1 location	EOO < 100 km² or AOO < 10 km² or 2-4 locations	EOO < 5,000 km² or AOO < 500 km² or 5-9 locations	EOO < 20,000 km² or AOO < 2,000 km² or 10+ locations	EOO > 20,000 km² or AOO > 2,000 km²	Unknown	5
Population decline	Extreme	>= 80% decline	>= 50% decline	>= 30% decline	None	Unknown	10
Fragmentation	Severe fragmentation	Isolated populations	Somewhat isolated populations	Relatively connected populations	Connected populations	Unknown	20
Regeneration/ recruitment	No regeneration or recruitment	Decline of >50% predicted in next generation	Insufficient to maintain current population size	Sufficient to maintain current population size	Sufficient to increase population size	Unknown	10
Genetic variation/ integrity	Extremely low	Low	Medium	High	Very high	Unknown	-
						Average vulnerability score	10.0
						Rank relative to all U.S. oak species of concern (out of 19)	9

THREATS TO WILD POPULATIONS

High Impact Threats

Human use of landscape — residential/commercial development, mining, and/or roads: Suburban sprawl, especially in the San Gabriel Valley, is causing Engelmann oak populations to become fragmented to the point of falling rates of pollination and acorn production.[1] Because fire damage to the trees is generally low in grasslands, moderate in scrub, and high in chaparral, continued human development of grassland areas could leave remaining Engelmann populations at greater risk to fire in chaparral communities.[5]

Human modification of natural systems — disturbance regime modification, pollution, and/or eradication: Another effect of development is the increasing risk of human induced wildfire. The entire range Engelmann oak exists within these higher-risk areas. Two of the largest wildfires in California burned extensive portions of the species' range in the 2000's. The 2003 Cedar Fire burned about 53% of monitored trees within Santa Ysabel Open Space Preserve, where the vast majority of Engelmann oak's total population is located.[5]

Climate change — habitat shifting, drought, temperature extremes, and/or flooding: Climate change models based solely on habitat suitability predict climate change to be the largest threat to *Q. engelmannii*, which is worrying since such models often underestimate the total impact of climate change.[6] A recent analysis of U.S. tree vulnerability to climate change found *Q. engelmannii* to have "potential future vulnerability" based on species-specific traits, due to low threat exposure but high threat sensitivity and low adaptive capacity.[7] Engelmann oak is also predicted to experience net habitat losses under combined impacts (climate change and land use changes), even under best-case unlimited dispersal scenarios.[8] Negative impacts due to increased periods of extreme heat, whiplash precipitation cycles (extremely wet to extremely dry), and consecutive years of drought are predicted; such conditions also increase the threat of severe fire (J. Henrich pers. comm., 2018).

Moderate Impact Threats

Human use of landscape — agriculture, silviculture, ranching, and/or grazing: Reproduction of Engelmann oak on the Santa Rosa Plateau is insufficient to maintain its current distribution, abundance, and demography.[9] This is attributed to past, nearly continuous grazing of the area for the last 75 years, causing soil compaction and damage to existing trees.[1] In some areas, livestock grazing is still a substantial threat.[10]

Pests and/or pathogens: There is recent concern regarding Polyphagous and Kuroshio shot hole borers (PSHB/KSHB) in southern California. These beetles are a host for the pathogenic fungus *Fusarium euwallaceae*, which they carry as they bore into the trunks and branches of trees for reproduction.[11] The fungus is harmful to *Q. engelmannii* and has spread throughout Los Angeles and San Diego Counties. It is very difficult to detect before it is too late (T. Thibault pers. comm., 2016). Goldspotted oak borer injuries have also been observed on dead Engelmann oaks "but tree mortality...was likely a result of a complex of factors (e.g., drought and root disease)."[12]

CONSERVATION ACTIVITIES

In 2017 *Quercus* accessions data were requested from *ex situ* collections. A total of 162 institutions from 26 countries submitted data for native U.S. oaks (Figures 3 and 4). Past, present, and planned conservation activities for U.S. oak species of concern were also examined through literature review, expert consultation, and conduction of a questionnaire. Questionnaire respondents totaled 328 individuals from 252 organizations, including 78 institutions reporting on species of concern (Figure 6).

Results of 2017 *ex situ* survey	
Number of *ex situ* collections reporting this species:	20
Number of plants in *ex situ* collections:	566
Average number of plants per institution:	28
Percent of *ex situ* plants of wild origin:	77%
Percent of wild origin plants with known locality:	99%

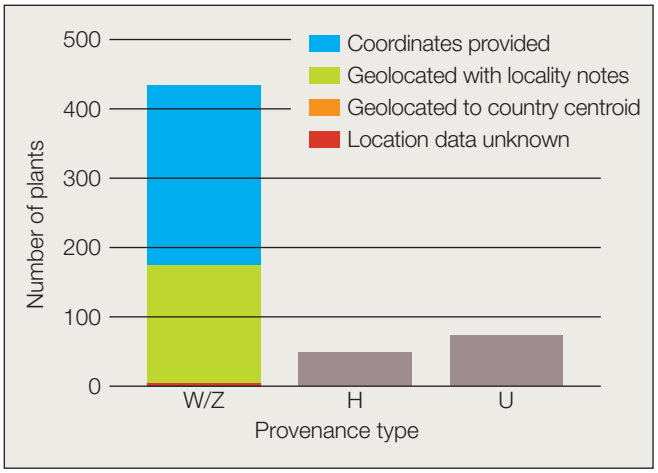


Figure 3. Number and origin of *Quercus engelmannii* plants in *ex situ* collections. Provenance types: W = wild; Z = indirect wild; H = horticultural; U = unknown.

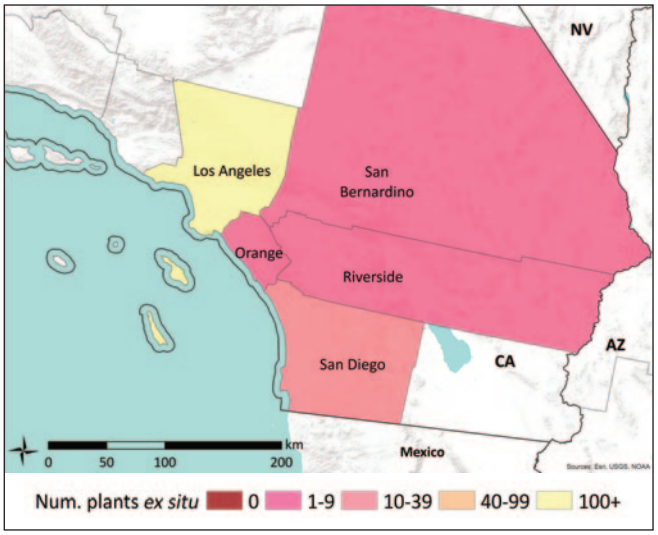


Figure 4. *Quercus engelmannii* counties of *in situ* occurrence, reflecting the number of plants from each county in *ex situ* collections.

A spatial analysis was conducted to estimate the geographic and ecological coverage of *ex situ* collections (Figure 5). Only the native U.S. distribution of the species was considered in this analysis, due to availability of ecoregion maps. Fifty-kilometer buffers were placed around each *in situ* occurrence point and the source locality of each plant living in *ex situ* collections. Collectively, the *in situ* buffer area serves as the inferred native range of the species, or "combined area *in situ*" (CAI50). The *ex situ* buffer area represents the native range "captured" in *ex situ* collections, or "combined area *ex situ*" (CAE50). Geographic coverage of *ex situ* collections was estimated by dividing CAI50 by CAE50. Ecological coverage was estimated by dividing the number of EPA Level IV Ecoregions present in CAE50 by the number of ecoregions in CAI50.

Estimated *ex situ* representation	
Geographic coverage:	74%
Ecological coverage:	79%

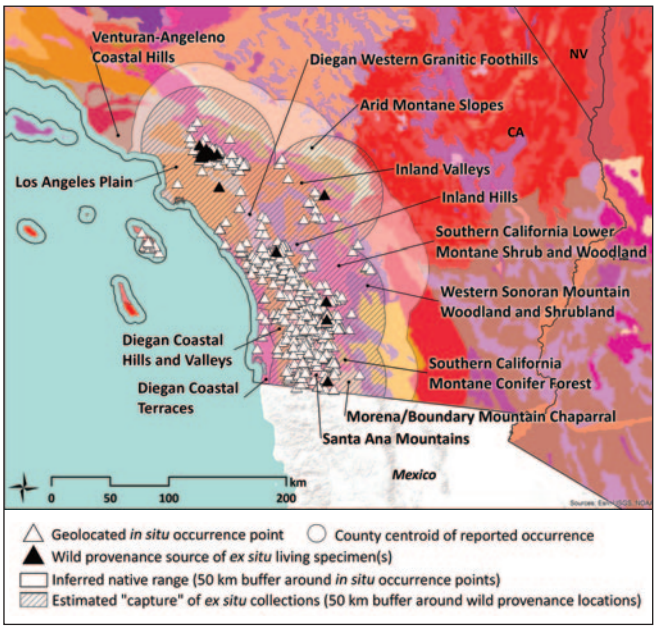


Figure 5. *Quercus engelmannii in situ* occurrence points and *ex situ* collection source localities within the United States. U.S. EPA Level IV Ecoregions are colored and labelled.[13] County centroid is shown if no precise locality data exist for that county of occurrence. Email treeconservation@mortonarb.org for more information regarding specific coordinates.


James Bailey

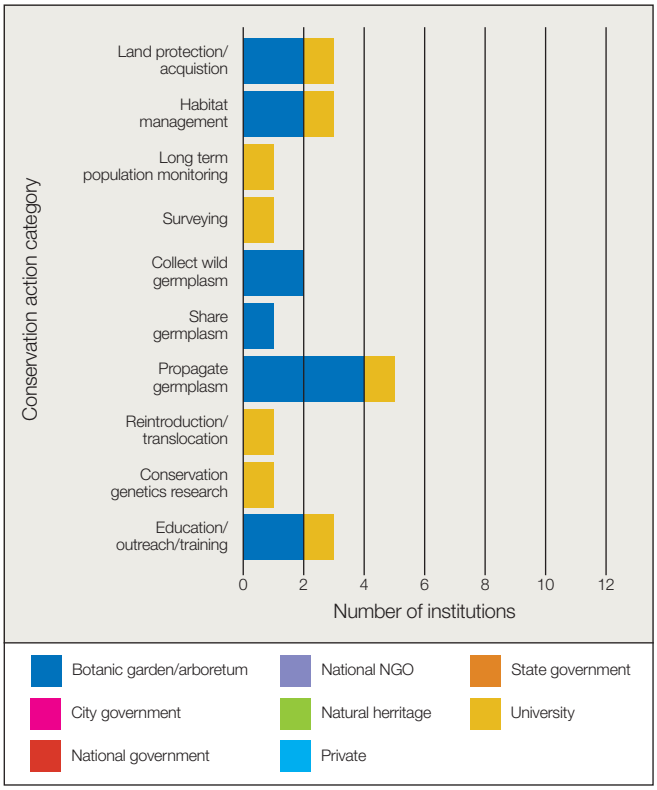


Figure 6. Number of institutions reporting conservation activities for *Quercus engelmannii* grouped by organization type. Six of 252 institutions reported activities focused on *Q. engelmannii* (see Appendix D for a list of all responding institutions).

Land protection: Within the inferred native range of *Q. engelmannii* in the U.S., 49% of the land is covered by protected areas (Figure 7). However, there are some sizable, healthy populations on protected land.

A USDA Forest Service report explains the status of protected *Q. engelmannii* populations in 1991: "the U.S. Forest Service has the largest tracts of Engelmann oak woodlands under one management, and provides the best opportunity for comprehensive planning for the conservation and management of the species. Land Grants, particularly those which have not been divided into subunits, provide the next largest group of undivided woodland areas...The greatest challenge in Engelmann oak conservation occurs in the small parcels which share 36% of all Engelmann oak woodlands."[14]

A Multiple Habitat Conservation Plan (MHCP) for the cities of Carlsbad, Encinitas, Escondido, Oceanside, San Marcos, Solana Beach, and Vista also provides protection for *Q. engelmannii*. In total there are 230 acres of Engelmann oak vegetative community, which conserves 82% of the species potential habitat and 84% of the main populations within the counties.[10]

Some significant populations are also held within public gardens, including The Los Angeles County Arboretum, which has a population of nearly 250 Engelmann oak trees and is the largest remaining extant population in Los Angeles County.[1] A smaller, neighboring subpopulation can be found at Santa Anita Park, as well as another small stand within Huntington Botanical Gardens in San Marino.[7]

Sustainable management of land: The Santa Rosa Plateau is the only preserve established specifically for Engelmann oaks and is managed by The Nature Conservancy.[1] At their Ecological Reserve located at the southern end of the Santa Ana Mountains, experimental management fires of the grass-layer were initiated in 1988, along with test burns in Riverside County (now the northernmost ecologically-intact population of *Q. engelmannii*) and Santa Ysabel Open Space Preserve.[13] The Los Angeles County Arboretum & Botanic Garden has claimed responsibility for the growth and management of a remnant stand of Engelmann oak within their property and adopted a four-phase management program, which begins with weed abatement and fostering successful establishment of natural recruits.[1] The MHCP for the cities of Carlsbad, Encinitas, Escondido, Oceanside, San Marcos, Solana Beach, and Vista requires subarea plans to implement a fire management plan in all conserved populations.[10]

Population monitoring and/or occurrence surveys: One institution reported this activity in the conservation action questionnaire, but no other details are currently known.

Wild collecting and/or *ex situ* curation: At the easternmost edge of the species' range is Rancho Santa Ana Botanic Garden in Claremont. Since the late 2000's, they have established a *Q. engelmannii* grove through acorn collection from isolated, wild individuals ranging from Pasadena to Monrovia.[7]

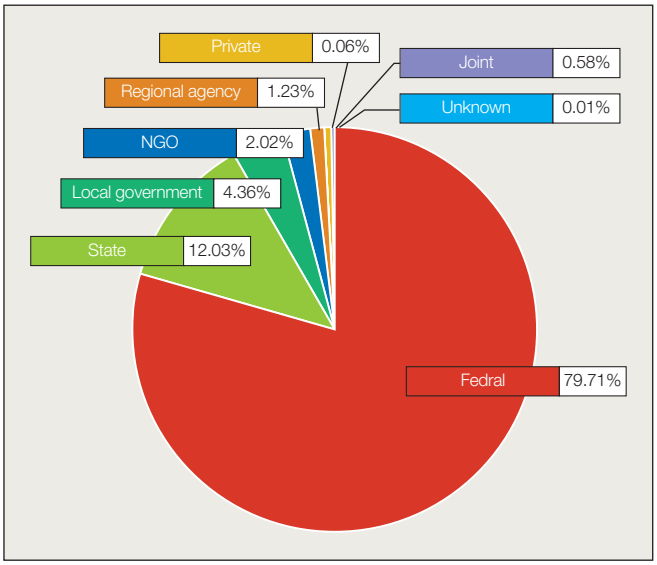


Figure 7. Management type of protected areas within the inferred native range of *Quercus engelmannii*. Protected areas data from the U.S. Geological Survey Gap Analysis Program (GAP) 2016 Protected Areas Database of the U.S. (PAD-US).[4]

Propagation and/or breeding programs: The LA County Arboretum's third phase of management for their native *Q. engelmannii* grove requires supplementing natural recruits with nursery-grown saplings from field-collected acorns, which includes the propagation of hundreds of seedlings.[1] Organizations such as the Arroyo Seco Foundation have sold thousands of trees to parks and natural areas by collecting acorn donations and then propagating them each year. The Tree of Life Nursery has been producing native California plants for more than two decades and is one of the largest suppliers of native plants in the state. Their grounds are located within Engelmann oak's native range, and include 30 acres of growing area in addition to laboratory facilities. They propagate a wide variety of native oak species, and are especially well known for their production of Engelmann oak seedlings in collaboration with conservation groups working to restore the species.[15]

Reintroduction, reinforcement, and/or translocation: The LA County Arboretum is supplementing their native stand of *Q. engelmannii* with seedlings grown from wild collected acorns they have propagated in their nursery.[1] The MHCP for the cities of Carlsbad, Encinitas, Escondido, Oceanside, San Marcos, Solana Beach, and Vista requires subarea plans to enhance declining populations, including reinforcement of existing populations. They require that "unless analyses determine that there is no significant genetic variation between populations, introduced plant materials must be from the parental population or a population in proximity."[10]

Research: As a result of their restoration program, LA County Arboretum reports a variety of findings: "supplemental irrigation is necessary to reduce leaf drop, and maintain health and vigor in the greater Los Angeles area; protecting natural recruits from mechanical damage increases survival rates; *ex situ* sapling production is very successful; and, vegetating with *ex situ* saplings is successful when planted during winter/spring precipitation periods, supplemental irrigation is applied, and protection is provided to prevent mechanical damage."[1]

Utilizing dynamic species distribution models, a study examined the interaction of *Q. engelmannii* life history traits and short-term and long-term climate change projections, to predict the species abundance in the future. These models incorporated data regarding land use change, altered fire frequency, and dispersal and seed predation. Results predicted "dramatic reduction in *Q. engelmannii* abundance, especially under drier climates and increased fire frequency."[16] Another study examined connections between the climate gradient of Engelmann oak's distribution and its spatial genetic structure by combining information from nuclear microsatellite markers and ecological niche modelling. Three main genetic clusters emerged, suggesting that local environmental conditions can influence spatial genetic structure, "even in species with high potential for gene flow and relatively small distribution ranges."[17]

Education, outreach, and/or training: The California Native Plant Society provides information to homeowners regarding the tree's use in landscape, including ecological requirements and locations for purchase. The East Palo Alto Tree Initiative, a "multi-year collaboration to enhance the urban forest in East Palo Alto and plant more than 1,200 trees," included *Q. engelmannii* in their urban plantings, in which hundreds of volunteers participated.[18]

Species protection policies: The city of Los Angeles has adopted a Protected Tree Ordinance that inhibits the removal or relocation of all California native oak species unless a permit is obtained through the Board of Public Works. The Board may require the planting of multiple protected trees within the same property's boundaries in addition to a fee for the removal or relocation of a native oak.[19]

PRIORITY CONSERVATION ACTIONS

Wildfire damage to established native stands, habitat fragmentation and loss due to urbanization, and lack of regeneration are principal reasons for the dramatic decline of Engelmann oak. Climate change and ongoing drought issues also complicate sustenance of natural populations. Protected outplanting in preserve areas within the native range and in other suitable locations may aid in maintaining this rare species. Establishment of suitable conditions for natural regeneration, such as in areas protected by gaps in established stands of native shrub species, could also be key to the perpetuation of this species in natural landscapes. Further research may be needed to inform effective restoration protocols. About 36% of Engelmann oak woodlands exist in small land parcels.[13] Therefore, outreach to individual landowners regarding techniques for sustainable management of oak woodlands will be an important component of the species' conservation. Continued monitoring of wild populations is also necessary, which will aid in the prediction of climate impacts. Further wild collecting for *ex situ* preservation should be carried out, targeting edge populations not yet held in *ex situ* collections. Engelmann oak is also predicted to experience net habitat losses under combined impacts (climate change and land use changes), even under best-case unlimited dispersal scenarios. Therefore dispersal will be vital to assuaging future habitat loss.[8]

Conservation recommendations for *Quercus engelmannii*

Highest Priority

- Education, outreach, and/or training
- Reintroduction, reinforcement, and/or translocation

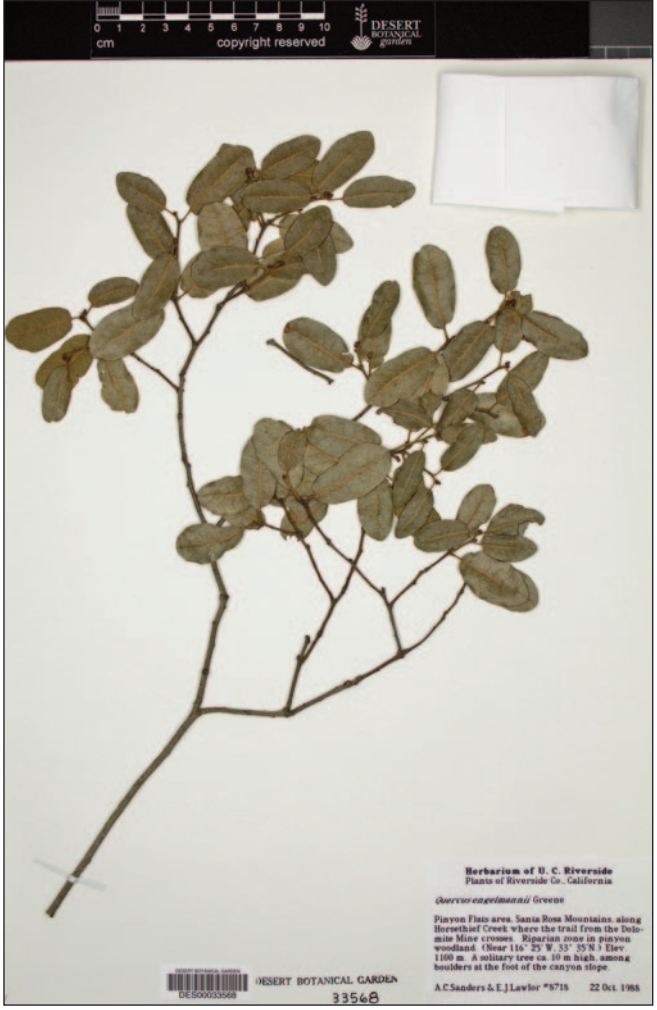
Recommended

- Population monitoring and/or occurrence surveys
- Research (land management/disturbance regime needs; pests/pathogens; restoration protocols/guidelines)
- Sustainable management of land
- Wild collecting and/or *ex situ* curation

REFERENCES

1. **Henrich, J. (2012, January).** The most majestic southern California oak. *Pacific Horticulture*, 78. Retrieved from https://www.pacifichorticulture.org/articles/the-most-majestic-southern-california-oak/
2. **Rosatti, T. J. & Tucker, J. M. (2014).** *Quercus engelmannii*. In Jepson Flora Project (Eds.), Jepson eFlora, Revision 2. Retrieved from http://ucjeps.berkeley.edu/eflora/eflora_display.php?tid=40590
3. **Kartesz, J. T. (2018).** The Biota of North America Program (BONAP). Taxonomic Data Center, Floristic Synthesis of North America, Version 1.0. Chapel Hill, NC. Retrieved from http://www.bonap.net/tdc
4. **U.S. Geological Survey, Gap Analysis Program (GAP). (2016, May).** Protected Areas Database of the United States (PAD-US). Version 1.4 Combined Feature Class. Retrieved from https://gapanalysis.usgs.gov/padus/data/download/
5. **Principe, Z. (2015).** Influence of fire on Engelmann oak survival – patterns following prescribed fires and wildfires. In *Proceedings of the seventh California oak symposium: managing oak woodlands in a dynamic world* (Gen. Tech. Rep. PSW-GTR-251). Berkeley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. Retrieved from https://www.fs.usda.gov/treesearch/pubs/49983
6. **Potter, K. M., Crane, B. S., & Hargrove, W. W. (2017).** A United States national *prioritization framework for tree species vulnerability to climate change. New Forests, 48(2), 275-300. doi:10.1007/s11056-017-9569-5*
7. **Eubank, S. C. (2008).** Discovery trails: Engelmann oaks (*Quercus engelmannii*) in Los Angeles County and their future. Los Angeles County Arboretum and Botanic Garden. Retrieved from https://www.biodiversitylibrary.org/part/144701#/summary
8. **Riordan, E. C., Gillespie, T. W., Pitcher, L., Pincetl, S. S., Jenerette, G. D., & Pataki, D. E. (2014).** Threats of future climate change and land use to vulnerable tree species native to southern California. *Environmental Conservation*, 42(2), 127-138. doi:10.1017/S0376892914000265
9. **Lathrop, E. W., Osborne, C., Rochester, A., Yeung, K., Soret, S., & Hopper, R. (1991).** Size class distribution of *Quercus engelmannii* (Engelmann oak) on the Santa Rosa Plateau, Riverside County, California. In Standiford, R. B. (Tech. coord.), *Proceedings of the symposium on oak woodlands and hardwood rangeland management; October 31 - November 2, 1990; Davis, California* (Gen. Tech. Rep. PSW-GTR-126). Berkeley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. Retrieved from https://www.fs.usda.gov/treesearch/pubs/28460
10. **California Dept. of Fish and Game, U.S. Fish and Wildlife Service, & Conservation Biology Institute. (2003, March).** *MHCP biological monitoring and management plan*. CA: Multiple Habitat Conservation Program. Retrieved from https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=35105
11. **Stouthamer, R., Rugman-Jones, P., Eskalen, A., Kabashima, J., Dimson, M., Gonzalez, A., Arakelian, G., Hodel, D., Drill, S. (2017).** Polyphagous shot hole borer. CA: Department of Entomology & Department of Plant Pathology and Microbiology, University of California.


Jim Henrich



12. **Colman, T. W., Jones, M. I., Smith, S. L., Venette, R. C., Flint, M. L., & Seybold, S. J. (2017).** Goldspotted Oak Borer. Forest Insect & Disease Leaflet 183. U.S. Department of Agriculture, Forest Service. Retrieved from https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3833276.pdf
13. **U.S. EPA Office of Research & Development. (2013, April).** Ecoregions of the Conterminous United States. National Health and Environmental Effects Research Laboratory (NHEERL). Retrieved from ftp://ftp.epa.gov/wed/ecoregions/us/us_eco_l4.zip
14. **Scott, T. A. (1991).** The distribution of Engelmann oak (*Quercus engelmannii*) in California. In *Proceedings of the symposium on oak woodlands and hardwood rangeland management; October 31 - November 2, 1990* (Gen. Tech. Rep. PSW-GTR-126). Berkeley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture. Retrieved from https://www.fs.usda.gov/treesearch/pubs/28457
15. **McCreary, D. D. (2001).** *Regenerating rangeland oaks in California*. Oakland, CA: University of California, Agriculture and Natural Resources. Retrieved from https://anrcatalog.ucanr.edu/pdf/21601e.pdf
16. **Conlisk, E., Lawson, D., Syphard, A. D., Franklin, J., Flint, L., Flint, A., & Regan, H. M. (2014).** Correction: The roles of dispersal, fecundity, and predation in the population persistence of an oak (Quercus engelmannii) under global change. *PLOS ONE*, 9(1). Retrieved from https://doi.org/10.1371/annotation/819da56b-1c8f-445f-80fc-e8d741dc2262
17. **Ortego, J., Riordan, E. C., Gugger, P. F., & Sork, V. L. (2012).** Influence of environmental heterogeneity on genetic diversity and structure in an endemic southern Californian oak. *Molecular Ecology*, 21(13), 3210-3223. doi:10.1111/j.1365-294x.2012.05591.x
18. **Canopy. (n.d.).** East Palo Alto tree initiative. Retrieved from http://canopy.org/our-work/tree-planting/east-palo-alto-tree-initiative/
19. **City of Los Angeles. (2006).** Los Angeles Municipal Code. Ordinance No 177404. Chap 1 $ 5.