Oaks

SPRING/SUMMER 2022 CALIFORNIA OAKS

# California's Oaks in the 21st century: Mapping oak woodlands and forests

*by Tom Gaman, Registered Professional Forester*

This report provides a new estimate of the area of California oak forests and woodlands utilizing spatial imputations created by LEMMA (Landscape Ecology, Modeling, Mapping, and Analysis, lemma.forestry.oregonstate.edu). LEMMA is a collaborative research group of the U.S. Forest Service Pacific Northwest Research Station and Oregon State University. LEMMA staff model forest structure and composition using Landsat imagery[1] and other environmental variables, in combination with U.S. Forest Service's Forest Inventory and Analysis (FIA)[2] ground-based survey plot data, to create Gradient Nearest Neighbor (GNN) structure maps. As explained on its website, LEMMA uses the GNN method to develop predictive vegetation maps covering all forest and woodland areas of Oregon, Washington, and California at 30-meter (0.22-acre) pixel resolution. LEMMA provided its first comprehensive statewide map and dataset using Landsat imagery and forest inventory ground plots available through 2012, and recently provided updated analyses using data that extend through 2017. Both analyses provide high-resolution, predictive vegetation maps with supporting attribute tables.

Each georeferenced, 30-meter grid cell throughout the three states is assigned attribute values depicting forest type, form, size, species prevalence, canopy density, basal-area dominance by species, trees per hectare, and others. The resulting Geographic Information System (GIS) raster database is useful for oak forest and woodland assessment because the model imputes, or estimates, species composition, forest form, tree size, and many other variables that characterize our forests. Nearby ground-based U.S. Forest Service FIA survey plots provide local calibration for forests and woodlands that meet a minimum threshold of 10% canopy cover.



"Oaks are ambassadors of time." — Lillian (Lolly) Mello Grady

**Oak woodlands and forests**

The foothills and rangelands of California are well-known for their iconic oak woodlands, where oaks dominate, but are often accompanied by other conifer and hardwood species such as gray pine, bay, and madrone. Oak forests are more subtle. Such forests are typically dominated by conifers such as Douglas fir, ponderosa pine, and other conifer species, but they also include oak hardwood associates that play important ecological roles.

The GNN mapping program assigns to each pixel the overall dominant, or plurality, species in addition to the plurality hardwood and the plurality softwood species. For this project the author characterized oak wood-

*— continued on page 2*

*— continued from page 1*

lands as vegetation types where an oak species was determined to be the overall plurality species. In other cases where the overall dominating plurality species is a conifer and the plurality hardwood is an oak or tanoak, such types are classified as oak forests, where oaks are the major hardwood but the overall plurality species is a conifer. The map presented as figure 1 indicates 12.3 million acres of oak woodland and 6.6 million acres of oak forests.

**Oak and tanoak species plurality**

Basal area is literally the cross-sectional area of trees at breast height. It is a common way to describe density. Basal area can be expressed in metric units as square meters per hectare; or in the United States, it is commonly expressed in terms of square feet per acre. Within oak forests and oak woodlands, as described above, GNN identifies the imputed dominating or plurality oak or tanoak species by basal area on every 30-meter-by-30-meter pixel using a variable named HDWPLBA. Cumulatively, these grid-cells represent all oak forests and woodlands, but each area can also be broken down by species. Table 1, below, in columns 2 and 3, shows the area of oak woodland and forest type by plurality oak or tanoak species, using GNN 2017 mapping data.

The map presented as figure 2 on page 5 identifies the nine major California oak types by plurality oak species (*Quercus*) and tanoak (*Notholithocarpus densiflorus*). *Quercus* species include coast live oak (*Quercus agrifolia*), canyon live oak (*Q. chrysolepis*), blue oak (*Q. douglasii*), Engelmann oak (*Q. engelmannii*), garry oak (also known as Oregon white oak, *Q. garryana*), California black oak (*Q. kelloggii*), valley oak (*Q. lobata*), and interior live oak (*Q. wislizeni*).

**21 native California *Quercus* species**

In addition to the common oaks discussed in this report, California oaks include John Tucker oak (*Q. john-tuckeri*), Palmer oak (*Q. palmeri*), Santa Cruz Island oak (*Q. parvula*, including *Q. parvula* var. *tamalpaisensis*), and island oak (*Q. tomentella* Engelm.). These and other hybrids are not included because their present native extent in California is extremely limited, and/or their canopies may not reach the 10% area threshold that FIA uses to define forested land.

California scrub oak (*Q. berberidifolia*), Cedros Island oak (*Q. cedrosensis*), Muller oak (*Q. cornelius-mulleri*), Nuttall's scrub oak (*Q. dumosa* Nutt.), leather oak (*Q. durata*), island scrub oak (*Q. pacifica*), Sadler oak (*Q. sadleriana*), gray or desert shrub oak (*Q. turbinella*), and huckleberry oak (*Q. vacciniifolia*) are shrub oaks. While valuable oak species, they are not recognized on the FIA tree list and thus not mapped as oak types.

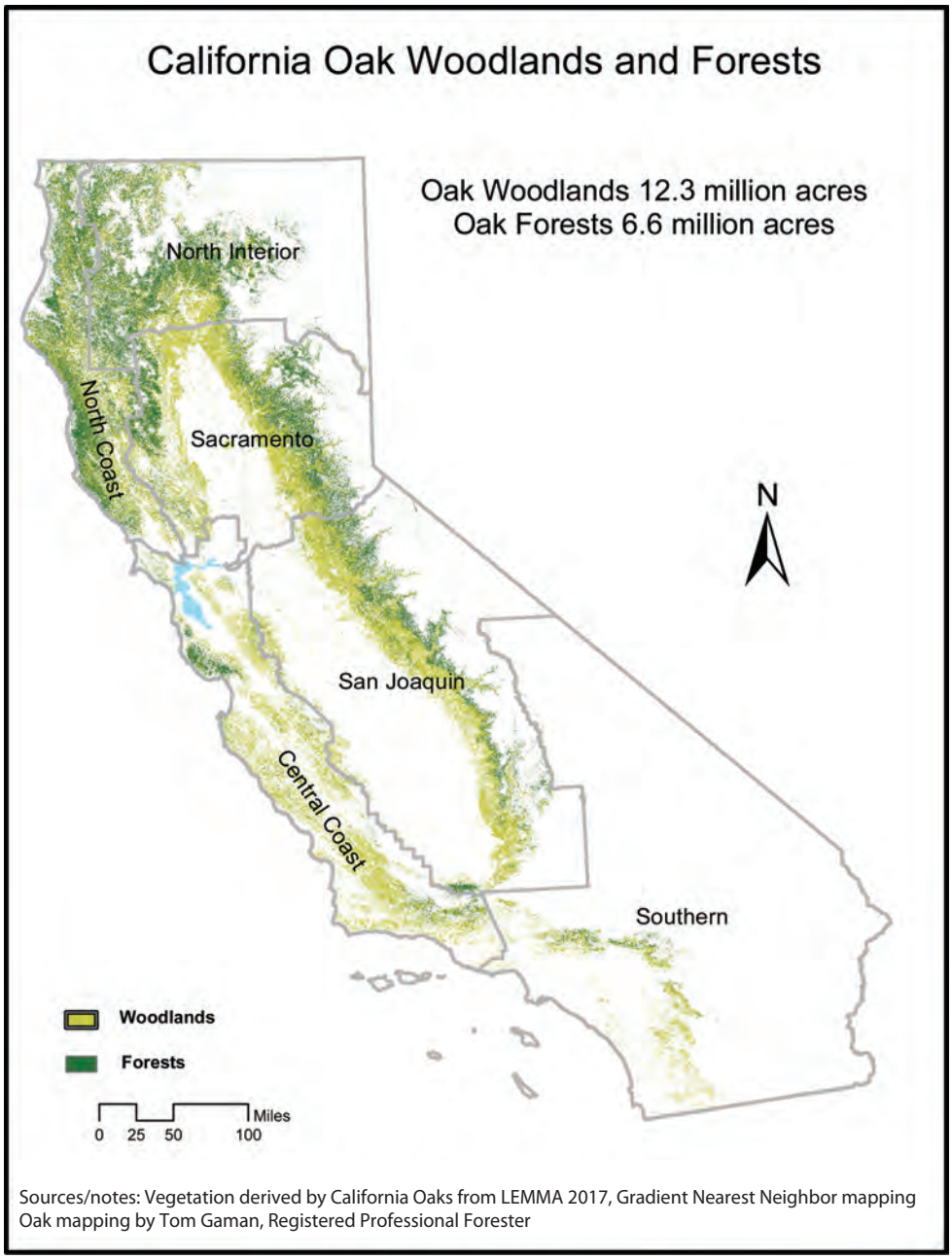



**Figure 1: California oak woodlands and oak-forested lands**

**Table 1: California oak woodland and forest types by plurality species**

| Oak plurality species | Woodland | Forest | Total woodland and forest |
|---|---|---|---|
| Tanoak | 958,509 | 1,559,200 | 2,517,709 |
| Coast live oak | 1,386,355 | 66,407 | 1,452,762 |
| Canyon live oak | 1,898,782 | 1,313,835 | 3,212,617 |
| Blue oak | 4,166,556 | 226,248 | 4,392,804 |
| Engelmann oak | 35,100 | 0 | 35,100 |
| Garry oak | 682,624 | 286,322 | 968,947 |
| Black oak | 1,464,909 | 2,802,362 | 4,267,270 |
| Valley oak | 352,666 | 32,382 | 385,048 |
| Interior live oak | 1,376,346 | 274,163 | 1,650,510 |
| **Total acres** | 12,321,847 | 6,560,919 | 18,882,767 |

**Comparison with other methods**

Many remote sensing and high-technology methods have been used to map California vegetation. These include Landfire[3] (www.usgs.gov/programs/gap-analysis-project/science/land-cover); U.S. Forest Service's Calveg program (www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192);

*— continued on page 5*

## How you can help:

- Donate to California Wildlife Foundation/California Oaks. A secure donation can be made from our website: californiaoaks.org.
- Spend time in an oak woodland or forest. Click on californiaoaks.org/resources for a partial listing of oak landscapes around the state that have public access.
- Please consider including oak conservation in your financial and estate planning efforts. Information can be found at: californiaoaks.org/donate.
- Be vigilant about threats to oak woodlands and oak-forested lands in your community and consult californiaoaks.org for guidance.
- Restore oaks to areas where they historically grew.
- Sign up for the *Oaks* e-newsletter at californiaoaks.org.
- Support local and statewide measures to protect natural resources.
- Hold decision-makers accountable for protecting green infrastructure.

California Oaks is a fund within California Wildlife Foundation, federal tax identification number 68-0234744. Contributions of cash, stocks, and bonds are tax deductible.


### *Acknowledgements*

**Special thanks** to Tom Gaman, California Wildlife Foundation/California Oaks (CWF/CO) Advisor, for his research and reporting on the status of California's native oak woodlands and oak-forested lands. Over decades, Tom has been in the forefront of informing Californians—from community groups to governors—about the state's primary old growth ecosystem. Thank you, Tom, for speaking up at every opportunity on behalf of oaks and their generous contributions to California.

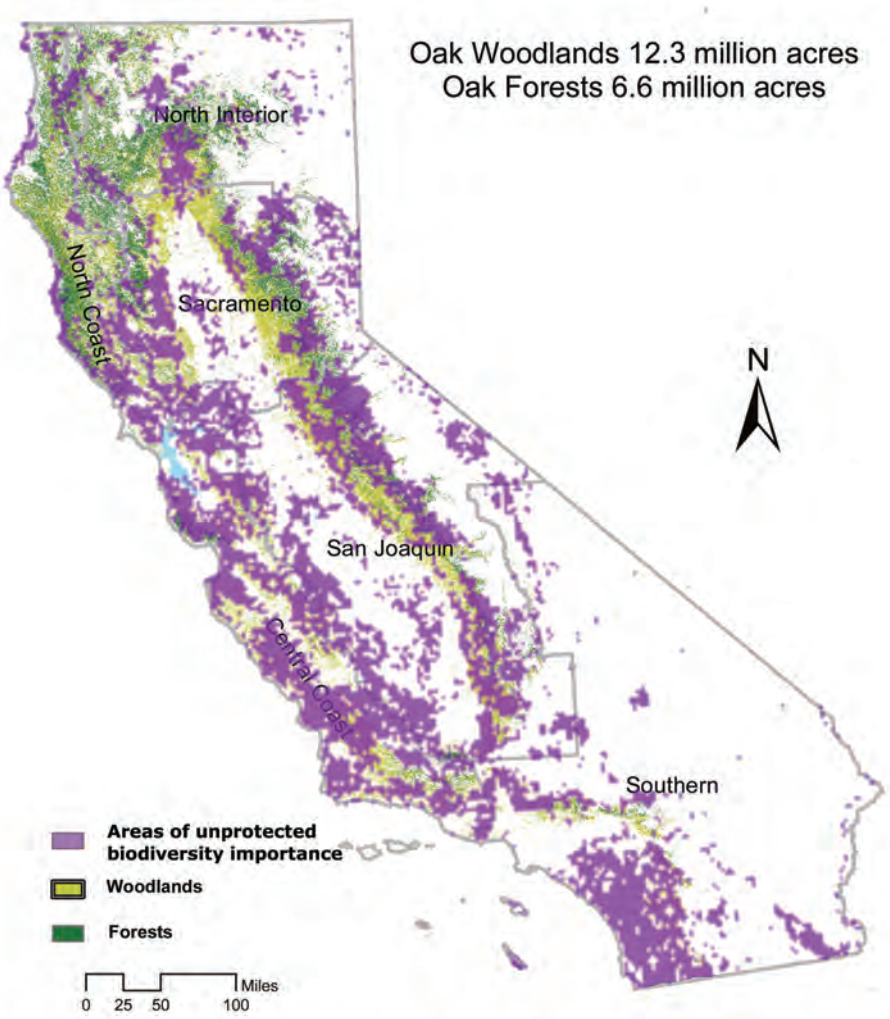
Gregory Matthew of the Landscape Ecology, Modeling, Mapping and Analysis (LEMMA) team reviewed the mapping article.

Nina Salvador Barroll prepared the overlay of Areas of Unprotected Biodiversity Importance, which is presented over oak woodland forest data on the map in columns 2 and 3.

CWF/CO Advisor Janet L. Byron provided editorial support and guidance in development of the newsletter, and CWF/CO Advisor Diane Walton reviewed the newsletter's articles.

Many thanks to CWF/CO's stellar volunteer, Rosemarie Aguilar, for her ongoing assistance.


## California Oak Woodlands and Forests and Areas of Unprotected Biodiversity Importance




Sources/notes: Vegetation derived by California Oaks from LEMMA 2017, Gradient Nearest Neighbor mapping
Areas of unprotected biodiversity importance mapping data from https://esajournals.online library.wiley.com/doi/10.1002/eap.2534

Oak mapping by Tom Gaman, Registered Professional Forester
Nina Salvador Barroll added the Areas of unprotected biodiversity importance layer

*At the state level, California stands out as having numerous opportunities to conserve currently unprotected, range-restricted imperiled species. With areas of unprotected biodiversity covering over one-quarter of the land area (and protected areas another 27%), much of the state either harbors or is in close proximity to suitable habitat for these species.*[1]

National Park Service biologists located a female bobcat in a cavity of a large oak tree in April 2021 using very high frequency radiotelemetry and Global Positioning System points from the mother's collar. She was in an area that was intensely burned during the Woolsey Fire that swept through Calabasas and other areas in the Santa Monica Mountains in November 2018. Photo courtesy of National Park Service, Santa Monica Mountains National Recreation Area.

[1] Hamilton H, Smyth LR, Young BE, et al., "Increasing taxonomic diversity and spatial resolution clarifies opportunities for protecting US imperiled species," *Ecological Applications* 2022;e2534. doi.org/10.1002/eap.2534

© Photo courtesy of William Campbell

Oaks in morning light, San Luis Obispo County

## California needs oak ecosystem accountability

Oaks are vital to sustaining California's unique resource wealth. The state's insufficient attention to oaks dovetails with its unprotected biodiversity. A report issued by NatureServe and collaborators estimates that 27.6% of California lands have unprotected biodiversity for all taxa, the highest level in the nation.[1] The map on page 3 overlays the "Areas of Unprotected Biodiversity Importance" map from the report atop oak woodlands and oak-forested lands.

The Spring-Summer 2021 issue of *Oaks* reported that 33 endangered or threatened (listed), candidate, and fully protected vertebrates are dependent upon oak habitat for reproduction, cover, or feeding, and 134 listed and candidate plants out of 839 sensitive native plant species and subspecies and 26 listed invertebrates out of 201 sensitive invertebrate species and subspecies are associated with oaks.

*A Shared Vision for the Survey of California Vegetation*, published by California State University Northridge's Center for Geographical Studies and California Department of Fish and Wildlife, presented the need for a comprehensive, high-resolution, statewide, digital vegetation map, created in compliance with the Survey of California Vegetation standards. This need, articulated in 2015, has yet to be met.[2]

California Wildlife Foundation/California Oaks issues this report as a challenge to decision makers to provide leadership so that the state conserves and tracks its critical oak ecosystem. California must do more to maintain and protect its primary old-growth resource by taking the following steps:

- Adopt a no-net-loss goal.
- Assess oak habitat regularly with statewide fine-scale mapping.
- Enforce existing protections of oaks.
- Protect oaks through groundwater sustainability plans.
- Restore beneficial fire to oak ecosystems.
- Partner with Indigenous communities to incorporate Traditional Ecological Knowledge about oak ecosystems.
- Provide financial incentives to perpetuate oaks on private lands throughout the state.
- Invest in education to engage the public in oak perpetuation.
- Conduct research to better understand oak stewardship under changing climatic conditions.
- Provide necessary resources to ensure oak regeneration efforts are successful.

All Californians must work together to keep our oaks standing—from children planting acorns in their classrooms to voters communicating with elected officials. We must protect the oak ecosystem for people, plants, wildlife, and invertebrates.

Sincerely,

Janet S. Cobb, Executive Officer
California Wildlife Foundation/California Oaks

[1] Hamilton H, Smyth LR, Young BE, et al., "Increasing taxonomic diversity and spatial resolution clarifies opportunities for protecting US imperiled species," *Ecological Applications* 2022;e2534. doi.org/10.1002/eap.2534

[2] Bram D, Most M, Hymel K, and Dark S. *A shared vision for the California Survey of Vegetation*: Center for Geographical Studies - California State University Northridge. 2015.

## California Oaks Coalition

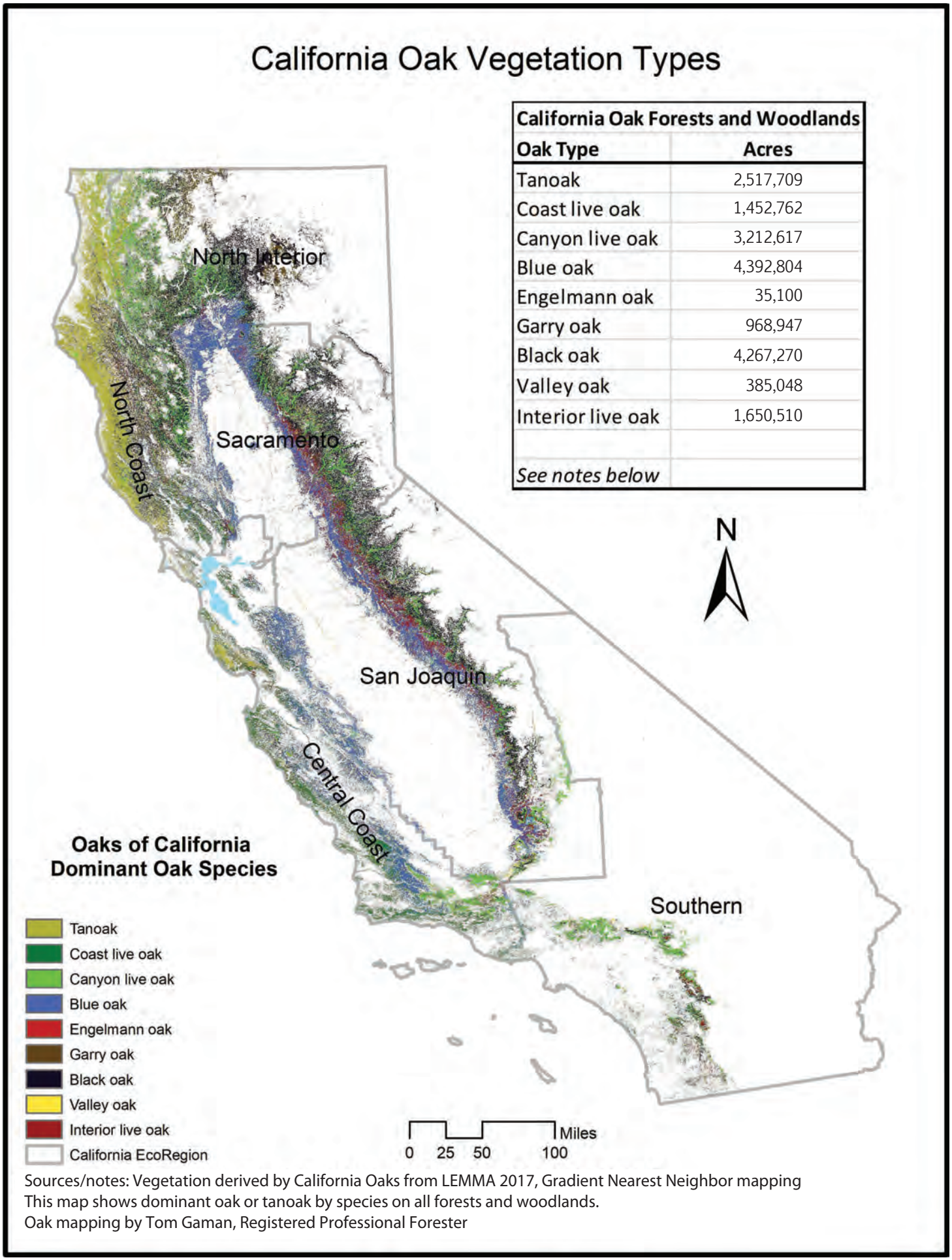
California Oaks Coalition brings together national, state, regional, and local organizations to conserve and perpetuate the state's primary old growth resource. Members of California Oaks Coalition are united by the vital role of oaks in sequestering carbon, maintaining healthy watersheds, providing habitat, and sustaining cultural values.

Amah Mutsun Land Trust; American River Conservancy; American River Watershed Institute; AquAlliance; Banning Ranch Conservancy; Butte Environmental Council; California Institute for Biodiversity (CIB); California Invasive Plant Council (Cal-IPC); California Native Plant Society (CNPS), including Dorothy King Young Chapter, San Diego Restoration Committee, and Sanhedrin Chapter; California Rangeland Trust; California State University Chico Ecological Reserves; California Water Impact Network (C-WIN); California Wilderness Coalition (CalWild); Californians for Western Wilderness (CalUWild); Canopy; Center for Biological Diversity (CBD); Central Coast Heritage Tree Foundation; Chimineas Ranch Foundation; Clover Valley Foundation; Conejo Oak Tree Advocates; Confluence West; Dumbarton Oaks Park Conservancy; Elder Creek Oak Sanctuary; Endangered Habitats Conservancy; Endangered Habitats League; Environmental Defense Center; Environmental Protection Information Center (EPIC); Environmental Water Caucus; Foothill Conservancy; Forests Forever; Friends of Harbors, Beaches and Parks; Friends of the Richmond Hills; Friends of Spenceville; Global Conservation Consortium for Oak; Hills For Everyone; Laguna de Santa Rosa Foundation; Lomakatsi Restoration Project; Los Padres ForestWatch; Lower Kings River Association; Northern California Regional Land Trust; Planning and Conservation League; Redbud Audubon Society–Lake County; Redlands Conservancy; Resource Conservation District of Santa Monica Mountains; River Partners; River Ridge Institute; Rural Communities United; Sacramento Tree Foundation; Santa Clarita Organization for Planning and the Environment (SCOPE); Save Lafayette Trees; Save Napa Valley; Sequoia Riverlands Trust; Shasta Environmental Alliance; Sierra Club Northern California Forest Committee–Oak Woodland Subcommittee; Sierra Club Placer Group; Sierra Foothill Conservancy; Tejon Ranch Conservancy; Tending the Ancient Shoreline Hill; Tuleyome; Tuolumne River Trust; University of California, Los Angeles, Mildred E. Mathias Botanical Garden; Woodland Tree Foundation

**California Oaks provides four areas of support for coalition members:**

1) Research and advocacy updates.
2) Information to educate and engage the public.
3) Tools for participating in planning processes and educating opinion leaders.
4) Materials to inform local, regional, and state governmental agencies of the opportunities for and benefits of protecting oak ecosystems.

For more information, please contact Oaks Network Manager Angela Moskow, amoskow@californiaoaks.org.




Sources/notes: Vegetation derived by California Oaks from LEMMA 2017, Gradient Nearest Neighbor mapping
This map shows dominant oak or tanoak by species on all forests and woodlands.
Oak mapping by Tom Gaman, Registered Professional Forester

**Figure 2: California oak woodlands and oak-forested lands**

*— continued from page 2*

CalFire's Fire and Resource Assessment Program (FRAP) (frap.fire.ca.gov), which created FVEG from a variety of vegetation mapping efforts; [4] and California Wildlife Habitat Relationship information system (wildlife.ca.gov/Data/CWHR). California Oaks, then known as California Oak Foundation, utilized Calveg data for the *Oaks 2040* publication in 2006.[5]

**Accuracy**

To assess accuracy of the forest and woodland mapping, a randomized grid of 110 50-by-50-meter plot data was overlaid upon pixels that had been classified by LEMMA 2012 as oak types.[6] Based on review that utilized National Agricultural Imagery Program (NAIP) imagery, and the author's experience with California oaks and FIA field surveys throughout the entire state, 91 of the 110 plots, or 85%, appeared to be correctly classified by LEMMA as oak types. There were also 7 plots mapped outside of oak types that appeared to be oaks. This outcome was similar to the LEMMA project's own accuracy assessment and added confidence to the decision to utilize GNN.

GNN was found to be suitable for estimating the seven most common oak types, but GNN 2017 erroneously classified some areas as Engelmann oak in several counties where that oak does not grow.[7] The GNN anomaly appears to be due to FIA field error, when a crew misidentified a large oak, possibly a blue oak, in Fresno County as an Engelmann oak, which was then imputed by GNN to similar habitats in nearby counties. Further, some areas designated as valley oak appeared questionable. It appears that GNN algorithms may have some difficulty correctly imputing the less-common types.

**Discussion**

Fine-scale mapping is an important component of all efforts to monitor the condition of California's oak ecosystems. Evolving ground-based methodologies, including FIA—alongside improved resolution of imagery, LIDAR methods, and precision interpretation of satellite imagery—are facilitating a better understanding of California oaks. GNN is certainly a useful tool for estimating California oak extent.

GNN estimation of oak forests and woodlands results in substantially greater acreage than *Oaks 2040*, where acreage was calculated based upon mapping only from aerial photos and other imagery. The GNN minimum polygon size is one single 30-meter-by-30-meter pixel (0.22 acre), and this represents a significant departure from traditional forest-type classification methodologies, which typically used a 5-acre minimum stand size. This anomaly may account for the increased imputed acreages. Regardless, direct comparisons cannot be made to acreage figures in *Oaks 2040* since methodologies used to estimate oak acreage were entirely different. *Oaks 2040* calculated combined woodland and oak-forested land acreage at 12,928,683 acres, compared to GNN's figure of 18,882,767 acres. In the intervening years since the publication of *Oaks 2040*, pressures on oaks—habitat conversion and fragmentation, changed rainfall patterns, diminishing groundwater supplies, greater climatic stress, new pathogens, expansion of invasive grasses, wildfires of extreme severity, and grazing and browsing pressure—have continued, and in some cases have escalated. Thus, it is not reasonable to consider that the larger acreage figure from analysis with GNN is an actual indication of improved conditions.

It is anticipated that results of GNN basal-area analysis will be presented in an upcoming issue of *Oaks*. In that publication the FIA plot data and GNN estimates of acreage, where oaks are present with a minimum basal area of 10-square-feet per acre for the nine species, will be presented and utilized to estimate carbon sequestered in oak woodlands and oak-forested lands.

---

[1] The NASA/USGS Landsat Program (landsat.gsfc.nasa.gov) provides a continuous, space-based record of Earth's land.

[2] FIA data are compiled by and available from the U.S. Forest Service (www.fs.usda.gov/srsfia/data_center/index.shtml). Also see: US Forest Service. 2013. Field Instructions for the Annual Inventory of California, Oregon and Washington. USDA-FS FIA Unit. Portland, OR, and US Forest Service. 2020 and FIA Data Mart: apps.fs.usda.gov/fia/datamart/CSV/datamart_csv.html

[3] Landfire is a shared program between the wildland fire management programs of the U.S. Department of Agriculture Forest Service and U.S. Department of the Interior, which provides vegetation mapping products.

[4] FRAP, in cooperation with California Department of Fish and Wildlife VegCamp program, and through extensive use of USDA Forest Service Region 5 Remote Sensing Laboratory (RSL) data, compiled the "best available" land cover data available for California into a single comprehensive statewide data set. The data span a period from approximately 1990 to 2014.

[5] Gaman T, Firman J, *Oaks 2040—The Status and Future of Oaks in California*. California Oak Foundation, 2006.

[6] USDA Farm Service Agency National Agricultural Imagery Program (NAIP) Data, 2020. Available at: www.usgs.gov/centers/eros/science/usgs-eros-archive-aerial-photography-national-agriculture-imagery-program-naip

[7] Seven counties—Amador, Calaveras, Fresno,-Madera, Mariposa, Tulare, and Tuolumne—were excluded from the Engelmann oak range map presented in this report.

© Black oaks in Yosemite National Park.

**California Wildlife Foundation**
**California Oaks Fund**
201 University Avenue #H-43
Berkeley, CA 94710
510.763.0282
**WWW.CALIFORNIAWILDLIFEFOUNDATION.ORG**

**Click on the Newsletters link of californiaoaks.org to download prior newsletters.**
**Newsletter design by**
**Darren Quin, Alpha Omega Print**