

# Oaks

SPRING/SUMMER 2026

CALIFORNIA OAKS

## Pest issues of valley and blue oaks in California

By Thomas F. Smith, PhD, Forest Entomology and Pathology Program, retired, California Department of Forestry and Fire Protection

California oaks provide numerous ecological benefits including biological diversity, wildlife habitat, carbon storage, clean air and water, and landscapes for recreation. Valley oak (*Quercus lobata*) and blue oak (*Q. douglasii*) are two of the major white oak species (subgroup *Quercus* or *Lepidobalanus*) in California. Numerous other white oak species exist within the state, however these two species have the most extensive ranges and some of the greatest environmental impacts.<sup>1</sup>

Many pest issues affect oaks in California. Biotic pests can attack any part of the oak tree through any stage in its development. The majority are native to the state and exist within a relative balance with their host trees, which they evolved with. Occasionally, some will reach outbreak levels due to environmental conditions, but will rapidly return to low endemic levels. These pests include leaf pathogens, root fungi, acorn insects, heart rot fungi, mistletoes, and gall insects, among others.

Invasive pest species (also called introduced, non-native, or exotic pests) have been introduced by humans over the years either by accident or on purpose. The host often shows no natural resistance to the organisms, resulting in severe damage or death of the trees. Some of these invasive species have been in California for decades while others are more recent introductions. Invasive pests generally cause little to no real damage in their native home ranges, having evolved in conjunction with their native range host plants.

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A healthy valley oak tree growing in Napa County.

### Insects

Among the native oak pest insects are various defoliators, bark and wood borers, acorn weevils, and gall insects. It is almost impossible to find an oak without some insects feeding or living on it; however, it is rare for the insects to cause significant damage except during an outbreak year, and extremely rare for the insects to cause tree mortality. Outbreaks may occur during specific environmental conditions or during extreme stress on the host tree, such as during periods of drought, after wildfires, or due to other stress factors.<sup>2</sup>

The invasive insect pest that is the greatest threat to blue and valley oaks is the Mediterranean oak borer, or MOB (*Xyleborus monographus*), a tiny ambrosia beetle from France. Ambrosia beetles introduce fungi into their host trees with the adults and developing larvae feeding exclusively on the fungus. The relationship is obligatory for both the insect and the fungus. Although gallery boring by the beetle causes structural damage, typically it is the fungi of ambrosia beetles that cause the dieback or mortality to the host plants by killing cells and plugging up the flow of water

and nutrients throughout the conducting tissues. The fungi and their role within the Mediterranean oak borer complex are still undergoing research. Initial observations indicate that the beetles attack the very top branches of the tree first and then slowly move down the host each year until they reach the main trunk. Insect galleries enter the woody interior of the tree, are dark black and lined with fungi, and tend to be arrayed along parallel planes with beetles freely moving between neighboring galleries. No other ambrosia beetle creates such distinctive lines of galleries in oaks. (See image on page 4.) Tree death can take from 5 to 10 years, but some individual trees appear to recover over time.

Larger valley oaks are the most susceptible. Blue oaks tend to be attacked only when stressed (such as from drought, extreme heat, or fire damage) or when growing in close proximity to infested valley oaks. A separate infestation in Oregon has resulted in extensive deaths of Oregon white oak with the source coming from a genetically distinct population from Germany. The California infestation began in Napa County, but has subsequently spread to Sonoma, Lake, Sacramento, and

— continued on page 4

## A concerted focus on blue and valley oaks



**The Wildlands Conservancy's Rana Creek Preserve, where the blue and valley oak conservation action planning workshop was held.**

Blue and valley oaks, two imperiled yet widely dispersed oak species, often co-occur, with blue oaks growing at higher altitudes and valley oaks in savannas and riparian corridors. Many populations are on private lands where the hydrology and vegetation have been dramatically altered for agricultural and other purposes. As Thomas Smith points out in this issue's cover article, humans pose the greatest threats to California's native oaks.

California Oaks and the Global Conservation Consortium for Oak convened a 3-day conservation action planning workshop in November 2025 to engage members of a blue and valley oak workgroup that has been meeting since April 2024 and other key stakeholders. Hosted by The Wildlands Conservancy, in collaboration with the Tribal Chairman of the Esselen Tribe, the workshop was held at a conference center at the newly established Rana Creek Preserve in Monterey County.

The workshop's emerging plan has three focus areas: *human-facilitated damaging factors*, *altered habitats*, and *land use*. We thank Dr. Smith, a member of the workgroup and presenter at the workshop, for the overview his article provides on oak pests. We also thank him for leading the group that generated conservation actions organized under five broad goals for the first focus area: 1. Limit the movement of infested soil, plants, wood, water, etc. 2. Increase production and use of pathogen and pest free nursery stock. 3. Increase monitoring of pests, pathogens, and plants. 4. Improve statewide management of invasive vertebrate herbivores. 5. Reduce avoidable human-caused damage to oak woodlands.

These goals and the associated actions require new policies, commitment to enforcement, and work across jurisdictions to address current and newly emerging pests and pathogens. Similarly, conservation actions to address altered habitats and land use will also require actions beyond what the workgroup alone can accomplish.

Workgroup participants include researchers, Tribal representatives, ranchers and land managers, regulatory agency and planning department professionals, restoration practitioners, botanic garden specialists, activists, land trust representatives, and educators. The group is leveraging its collective knowledge, connections, and perspectives to identify the path forward. Part of the path will be a roadmap to outline complementary actions needed by those who are not represented by the workgroup to benefit these two species.

We are grateful to the workgroup participants as well as the members of California Oaks Coalition who are working throughout the state on behalf of all of California's native oak species. Collaboration, coordination, and alignment across sectors are vital to keeping oaks standing.

Sincerely,

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

## California Oaks Coalition

California Oaks Coalition brings together international, national, Tribal, 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.

Alameda Native History Project  
Amah Mutsun Land Trust  
American River Conservancy  
American River Watershed Institute  
Anderson Valley Land Trust  
AquAlliance  
Audubon California  
Baduwa't Watershed Council  
Butte Environmental Council  
California Institute for Biodiversity  
California Invasive Plant Council (Cal-IPC)  
California Native Plant Society (CNPS),  
including Dorothy King Young, El Dorado,  
Sanhedrin, and Yerba Buena chapters and  
the San Diego Restoration Committee  
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  
Carrizo Plain Conservancy  
Center for Biological Diversity  
Central Coast Heritage Tree Foundation  
Chimieas Ranch Foundation  
Clover Valley Foundation  
Coastal Corridor Alliance  
Conejo Oak Tree Advocates  
Confluence West  
Dumbarton Oaks Park Conservancy  
Earth Discovery Institute  
El Cerrito Trail Trekkers  
Endangered Habitats Conservancy  
Endangered Habitats League  
Environmental Defense Center  
Environmental Protection Information  
Center (EPIC)  
Environmental Water Caucus  
The Fire Restoration Group  
Foothill Conservancy  
Forest Unlimited  
Forests Forever  
Friends of Harbors, Beaches and Parks  
Friends of Olompali  
Friends of Spenceville  
Friends of the Richmond Hills  
Global Conservation Consortium for Oak (GCCO)  
Hills For Everyone  
Laguna de Santa Rosa Foundation  
LandPaths  
Loma Prieta Resource Conservation District  
Lomakatsi Restoration Project  
Los Angeles Audubon Society  
Los Padres ForestWatch  
Lower Kings River Association

## RESOURCES

**The California Oak Disease and Arthropod host index database (CODA)** (<https://coda.phytosphere.com/>) is a comprehensive compilation of the diverse agents that affect oaks in California. CODA utilizes published and nonpublished data and observations and includes demonstrated interactions between California oaks and biotic agents (microbes, insects, mites, nematodes, etc.) as well as abiotic factors (e.g., extreme heat, drought, salinity). CODA's search capabilities allow users to determine potential causes of symptoms on oaks.

Some of the more prominent agents in CODA are discussed in greater detail in the *Field Guide to Insects and Diseases of California Oaks* (see below), with links to the corresponding agent write-up in the field guide added as these are updated. Further, CODA records are actively being updated to include the most recent information available.

***Field Guide to Insects and Diseases of California Oaks - Online Edition*** (<https://phytosphere.com/fieldguide/>) is an updated version of the original 2006 print and PDF edition of this field guide (<https://phytosphere.com/publications/Fieldguide.htm>). It includes the most damaging pests and diseases of oaks in California. Like CODA, the online format allows updates to be made as new information becomes available. This is especially important for damaging agents that are new and/or expanding. The new online version started with the pest and disease sections from the 2006 edition. Updated versions of these sections are added to the online version as they are completed. Several new sections have also been added and others are still being developed. The online field guide includes an e-book version that can be downloaded for use in areas without internet access.

*California Oaks distributed copies of the original field guide and hosts the PDF on our website. We also assisted Phytosphere Research in raising funds to support CODA and the updated field guide. We thank Phytosphere Research for advancing knowledge about protecting and perpetuating oaks.*

**Additional resources related to Phytophthora root rots** can be found at: [https://phytosphere.com/onlinelist\\_soilphytophthoras.htm](https://phytosphere.com/onlinelist_soilphytophthoras.htm)

*Also see the Further Resources (page 4) provided at the end of the article on pest issues.*

## Acknowledgements

The Board of Directors supports the important conservation efforts of California Wildlife Foundation/California Oaks (CWF/CO). We extend our deepest gratitude to Ellen Maldonado, Chair; Jim Lightbody, Treasurer; and Lynn Barris, Secretary, for their time and dedication to California's environment.

Many thanks also to CWF/CO intern Katherine Kerstetter for her editorial review of the articles, to CWF/CO Advisor Janet L. Byron for her review of the article on Antioch Dunes and editorial guidance, to Roderick Cameron of the International Oak Society Board of Directors for reviewing the international oaks article, to Amanda Gossard of the National Park Service for her assistance with the *in memoriam* article about Pauline Geisler, and to Cathryn Bangs, Stefani Berger, and Sonia Pang for assistance with mailing.

Micke Grove Zoo  
Mountains Recreation and Conservation Authority  
Northern California Regional Land Trust  
Ojai Trees  
Old-Growth Forest Network  
100K Trees for Humanity  
Pacific Birds Habitat Joint Venture  
Placer Land Trust  
Planning and Conservation League  
Point Blue Conservation Science  
Redbud Audubon Society–Lake County  
Redlands Conservancy  
Regrounding  
ReLeaf Petaluma  
Resource Conservation District of Santa Monica Mountains  
River Partners  
River Ridge Institute  
Rural Communities United  
Sacramento Tree Foundation  
Sacramento Valley Conservancy  
Santa Barbara Botanic Garden  
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  
Smith River Alliance  
Stewards of the Arroyo Seco  
Tejon Ranch Conservancy  
Tending the Ancient Shoreline Hill  
The Urban Wildlands Group  
Tuleyome  
Universidade de Trás-os-Montes e Alto Douro, Department of Forest and Landscape Architecture (Vila Real, Portugal)  
University of California Botanical Garden at Berkeley  
University of California, Los Angeles, Mildred E. Mathias Botanical Garden  
Ventura Land Trust  
Western Shasta Resource Conservation District  
Woodland Tree Foundation  
Yosemite Rivers Alliance (formerly Tuolumne River Trust)

### California Oaks provides the following support for coalition members:

- 1) Research and advocacy updates.
- 2) Collaboration in protecting oaks.
- 3) Information to educate and engage the public.
- 4) Tools for participating in planning processes and educating opinion leaders.
- 5) Materials to inform governmental agencies of the opportunities for and benefits of protecting oak woodlands.
- 6) Sharing stories from coalition efforts to keep oaks standing.

For more information, please contact Oak Project Director Angela Moskow, [amoskow@californiaoaks.org](mailto:amoskow@californiaoaks.org).



**This photograph shows the typical gallery pattern caused by Mediterranean oak borer in valley oak.**

— continued from page 1

Yolo counties, with positive trap catches but no known tree infestations yet found in Amador and El Dorado counties. Both the California and Oregon infestations are thought to have entered North America on wood used for barrel making in the wine industry.<sup>3</sup>

Another potential insect pest problem on blue and valley oaks may result from the invasive shot hole borer (ISHB) complexes. Three different complexes of *Euwallacea* beetles and their associated fungi (primarily *Fusarium* spp.—known plant pathogens) have been introduced into California—the Polyphagous, Kuroshio, and Greater shot hole borers. All three are ambrosia beetles, have large but similar host ranges, and originated in Asia. ISHB complexes likely entered California on infested woody packing material and have spread through human induced movement of infested wood, particularly the movement of firewood. The infestation of the Polyphagous shot hole borer (*E. formicatus*) began in Los Angeles County and has invaded much of Southern California, while the Kuroshio shot hole borer (*E. kuroshio*) was detected in San Diego County a few years later, and quickly spread from there.

Valley oak is a known host of ISHB in Southern California as well as another white oak species, the European common or English oak (*Q. robur*), a widely planted urban shade tree. The potential for blue oak is presently unknown. The insect causes staining of the bark and large crusted areas referred to as sugar volcanoes. Both the insect and its associated fungi can complete their life cycles completely within the host oak tree. Only a single insect is needed to begin a new infestation since the female beetles are pregnant when they fly to a new host, carrying their fungal symbiont. Within the new host tree, she will lay her eggs, and the resulting siblings will develop and mate with one another.<sup>4</sup>

In Northern California, a new infestation of ISHB was found in the City of San Jose closer to the more extensive valley and blue oak ranges. Presently, the pest complex is primarily in riparian and urban habitats and has yet to

enter major oak woodlands. Also, the Greater shot hole borer (*E. interjectus*) was discovered in the community of Felton in Santa Cruz County in 2025. Its potential host range and ability to spread are currently unknown.<sup>5</sup>

### Diseases

Plant pathogens include a variety of fungi, bacteria, viruses, nematodes, parasitic seed plants, and abiotic issues. There are many native oak diseases, but few are of major consequence to the trees. Among these pathogens are various foliar diseases that often cause the leaves to appear discolored or misshapen or may lead to early leaf senescence, a variety of heart rot fungi that can lead to wood decay and tree failure over time, leafy mistletoes, and some root diseases such as *Armillaria* spp. that can destroy roots and spread from tree to tree. Most native diseases are only issues when the host tree is either stressed or dying from extreme drought, insect defoliation, root compaction, abnormal heat, pollution, or other causes.<sup>2</sup>

An emerging disease issue for oaks in California is the transmission of various Phytophthora (*Phytophthora* spp.) root diseases from infested nursery stock through restoration plantings. Phytophthoras are not true fungi but are Oomycetes (water molds) that have swimming spores and are readily spread through soil movement, water flow, and human activities. Some Phytophthoras may be native to California and others are introduced. Most attack and kill the fine feeder roots of the host plants.

Unfortunately, many Phytophthoras have been found in nurseries where soil and plant material are being moved from site to site and water is spreading the disease organisms. When infested nursery plant stock is out-planted, the disease organisms may be moved with them, resulting in new infestations in previously uncontaminated sites. Most large commercial nurseries attempt to conduct operations in manners to reduce the potential spread of the pest organisms (nursery stock grown on raised platforms or on gravel to reduce soil exposure, clean water supplies, water management to reduce standing water, clean soil, and clean pots). However, many small independent nurseries do not follow these practices and have been sources of spread of the pathogens during restoration plantings. Once a site is infested it is nearly impossible to clear it of the diseases.<sup>6</sup>

### Weeds

The California landscape is home to many non-native invasive weedy plants that can impact valley and blue oaks. These species may reduce the ability of the trees to naturally

regenerate and establish new seedlings by crowding or out-competing them, can rob seedlings of needed water resources in the soil, or may alter natural fire regimes in ways detrimental to oaks and other trees, shrubs, and grasses. Yellow starthistle (*Centaurea solstitialis*) is particularly common in many California oak habitats. The plants have deep taproots that reduce soil water availability for oak seedlings. They produce extremely high numbers of seeds that can overwhelm a site and quickly establish on bare soil, leaving little opportunity for natural oak regeneration. Their thorns make them unpalatable for herbivory by many native and domesticated animals, and, lastly, they are prone to burning in manners that are not within the natural fire regime patterns and intensities found in the typical California oak woodland. Control has been difficult but attempted with the use of chemical herbicides, the introduction of bio-control organisms, and the judicious use of controlled burning. Presently, between 10 to 15 million acres of California are considered infested with yellow starthistle.<sup>7</sup>

### People

Indigenous Californians lived in a balanced state with oaks. Oaks were sacred, with acorns that provided a significant source of food for people and wildlife and oak habitats important for everyday life.<sup>1</sup> Unfortunately, recent activities of California's human population have resulted in significant losses of oak habitats through development, farming, ranching, and infrastructure. Oak woodlands have experienced severe fragmentation, the introduction of invasive species, pollution impacts, and changes in historic fire regimes. The fragmentation of oak woodlands results in a reduction of gene flow, the loss of intact habitats, reduced biodiversity, and the loss of ecosystem functions. People remain the greatest threat to blue and valley oaks in California.

### Further Resources

<sup>1</sup> Pavlik BM, et al. 1991. *Oaks of California*. Cachuma Press, Inc., Los Olivos, CA. 184 p.

<sup>2</sup> Swiecki TJ and EA Bernhardt (Eds.). Online edition 2026-03-24. *A field guide to insects and diseases of California oaks*. [phytosphere.com/fieldguide/](https://phytosphere.com/fieldguide/)

<sup>3</sup> [ucanr.edu/site/mediterranean-oak-borer](https://ucanr.edu/site/mediterranean-oak-borer)

<sup>4</sup> [ucanr.edu/site/invasive-shothole-borers](https://ucanr.edu/site/invasive-shothole-borers)

<sup>5</sup> [calfire-umb05.azurewebsites.net/media/ze2dnxry/full-13-a-i-greater-shothole-borer-handout\\_adamfk.pdf](https://calfire-umb05.azurewebsites.net/media/ze2dnxry/full-13-a-i-greater-shothole-borer-handout_adamfk.pdf)

<sup>6</sup> [suddenoakdeath.org/welcome-to-calphytos-org-phytophthoras-in-native-habitats/](https://suddenoakdeath.org/welcome-to-calphytos-org-phytophthoras-in-native-habitats/) Also see: [fs.usda.gov/psw/publications/documents/psw\\_gtr242/psw\\_gtr242.pdf](https://fs.usda.gov/psw/publications/documents/psw_gtr242/psw_gtr242.pdf)

<sup>7</sup> [ipm.ucanr.edu/home-and-landscape/yellow-starthistle/#gsc.tab=0](https://ipm.ucanr.edu/home-and-landscape/yellow-starthistle/#gsc.tab=0)

## International oaks



Khaoula El Khatib, a PhD candidate at Abdelmalek Essaâdi University in Morocco (left) and Angela Moskow Oak Program Director, California Wildlife Foundation (right).

Mexico has the greatest oak biodiversity in the world and more threatened oak species than any other country. It provided the ideal setting for the 11th International Oak Society conference in October 2025. Oak enthusiasts from over 20 countries gathered in the city of Oaxaca to discuss and explore a range of topics in 46 oral and 20 poster presentations. A big focus was genetic work that is helping to clarify the evolution of oaks, including oak biodiversity in Mexico, with impressive scholarship shared by many Mexican graduate students.

Other subjects included:

**Science:** Nomenclature and taxonomy, *in-situ* and *ex-situ* oak collections, oak cloud forest restoration, galls, foliar endophytic fungal communities, the suitability of foliar alkanes as biomarkers for paleoclimatic and paleoecological reconstruction studies, the potential of volatile organic compounds to induce defense in forest trees.

**Conservation:** Oak resilience to recent environmental changes, cryopreservation, *in-vitro* propagation, oak project-based learning and leadership development.

**Oaks and culture:** Acorns as a traditional source of nutrition in Morocco and the exploration of their utility for reducing food insecurity, the suitability of oaks for regenerative agricultural landscapes in Australia, oak trail marker trees, and sacred oaks in Serbia.

California Wildlife Foundation/California Oaks was represented by Oak Program Director Angela Moskow, who presented on the Oaks Underground report that was issued in the Spring-Summer 2024 Oaks newsletter ([californiaoaks.org/wp-content/uploads/2024/04/Oaks-Spring-24-Newsletterreduced.pdf](https://californiaoaks.org/wp-content/uploads/2024/04/Oaks-Spring-24-Newsletterreduced.pdf)).

As we navigate the challenges and opportunities that California's oak communities face, there is much to be learned from our colleagues around the world. Gabriela Wiener Castillo, of the Landscape Architecture Faculty of the Universidad Nacional Autónoma de México, presented on restoration of the Magdalena Contreras oak forest in Mexico City, where seven oak species are threatened by land use changes, illegal logging, and slow growth rates. She and her fellow researchers are collaborating with the local Indigenous community, mapping oak populations, and cataloging settlements in the area that maintain ecological and/or cultural ties to the forests. They are also observing the project within the Bosque de Agua (Water Forest) framework, which seeks to replenish groundwater basins for the city. We shared our Fall-Winter 2021 newsletter ([californiaoaks.org/wp-content/uploads/2021/10/Fall-Winter-2021-Newsletter-Reduced-Size-1.pdf](https://californiaoaks.org/wp-content/uploads/2021/10/Fall-Winter-2021-Newsletter-Reduced-Size-1.pdf)), which reports on oaks and groundwater recharge, and look forward to learning more about the Bosque de Agua framework.

Phillip Schulze, Arboretum and Natural Areas Manager of the Lady Bird Johnson Wildflower Center, presented on mapping and monitoring federally and state threatened Hinckley oak (*Quercus hinckleyi*) growing in Big Bend Ranch State Park in Texas. This is the only oak that is federally-designated under the Endangered Species Act. It reproduces clonally, like the Palmer's oak (*Q. palmeri*) growing in Riverside County, which is estimated to be 13,000 years old ([journals.plos.org/plosone/article?id=10.1371/journal.pone.0008346](https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0008346)). However, the Palmer's oak lacks state and federal protections and is threatened by proximate development. There may be lessons to be learned from Texas that will help develop protections for this imperiled relict.

Other notable conference events includ-

ed a satellite Mexico and Central American Species' Stewards meeting hosted by the Global Conservation Consortium for Oak, a festive awards dinner held at a culinary institute, an exhibit of beautiful botanical illustrations of Mexican oaks, pottery made in a nearby community decorated with oak bark dye, the sale of illustrations from the book *Oak Origins*, and a silent auction with oak objects from around the world.

The conference's 140-participants participated in half-day field trips to explore oaks in nearby oak forests or an ethnobotanic garden. Additionally, a pre-conference tour visited oaks in other parts of the country and post-conference tours went to oak landscapes in the Oaxaca environs.

Many thanks to Antonio González Rodríguez (director of the Conservation Genetics Lab at the Instituto de Investigaciones en Ecosistemas y Sustentabilidad at the Universidad Nacional Autónoma de México, Morelia, Michoacán) who served as the conference host, Béatrice Chassé (editor of *International Oaks* and Cofounder, Arboretum des Pouyouleix, France), conference chair, and the other members of the conference committee.



Professor Susana Valencia, Mexico's foremost expert on oaks, with dry *Quercus conzattii* leaves during a conference trip to a nearby cloud forest. Dr. Valencia presented the International Oak Society conference's keynote presentation, covering the history of the evolution of Mexican oaks, their importance, and their taxonomic mystery

## Ancient oak woodland sand dunes home to endangered species

© John Hamrah



**Lange's metalmark butterfly**

By Angela Moskow, California Oaks

The Antioch Dunes National Wildlife Refuge in Contra Costa County provides critical habitat for three federally endangered species: Antioch Dunes evening primrose (*Oenothera deltoides* ssp. *howellii*, also state endangered), Contra Costa wallflower (*Erysimum capitatum* var. *angustatum*, also state endangered), and Lange's metalmark butterfly (*Apodemia mormo langei*). These species evolved over millennia on sand dunes that once reached up to 115-feet along 2-miles of the southern banks of the San Joaquin River to the east of the Carquinez Strait. The 1-inch orange and black-winged Lange's metalmark butterfly is found nowhere else in the world, making Antioch Dunes its only refugia.

The Antioch Dunes—formed from the combination of wind-blown and riverine sedimentary processes acting over cycles of interglacial and glacial periods—were believed to support an oak woodland community with open areas of sand where endemic plants established, isolated from similar habitats.<sup>1,2</sup> Following the 1906 earthquake and subsequent fire, sand from these dunes was used to rebuild San Francisco. The sand mining, other development (including a paper mill, power plant, iron works, and sewage treatment facility), and invasion by exotic plant species destroyed much of the site's unique habitat. As sand disappeared, non-native grasses and plants crowded out the primrose, wallflower, and Antioch Dunes buckwheat, which is the only plant where the Lange's metalmark butterfly will lay its eggs.

Starting in 1869, scientific expeditions to Antioch Dunes documented its unique flora and fauna, followed by conservation efforts informed by this scientific inquiry.<sup>3</sup> Lange's metalmark butterfly was federally listed as endangered in 1976, and the Contra Costa wallflower and Antioch Dunes evening primrose received this designation in 1978. An upwelling of support for habitat protections was inspired by the issuance of endangered flora postage stamps in 1979, including one that depicted the Contra Costa wallflower and another the primrose. As a result, the office of U.S. Representative George Miller, who served the district, was overwhelmed with letters from plant and butterfly enthusiasts throughout the country seeking additional protections. At that time, the property's owners were negotiating with a developer interested in acquiring the site for a marina and condominium complex. Instead, U.S. Fish and Wildlife Service acquired 55 acres, which were designated as the Antioch

Dunes National Wildlife Refuge in 1980. The acquisition was accomplished with \$2,135,000 from the Land and Water Conservation Fund for the protection of these three endangered species, the first national refuge for insects and plants.<sup>4</sup> The 55-acre urban refuge with two non-adjacent units was also the nation's smallest.<sup>5</sup>

The refuge now includes an additional 12 acres of the same remnant dune ecosystem. Formerly owned by Pacific Gas and Electric (PG&E), these lands were managed under a cooperative agreement between PG&E and U.S. Fish and Wildlife Service until ownership was transferred to the refuge in 2022, thereby expanding it to 67-acres.

The site's Draft Comprehensive Conservation Plan and Environmental Assessment lists nine federal "species of concern," which are currently or were previously within or near the refuge: San Joaquin dune beetle (last seen in 1974 and believed to be extirpated from the site), Antioch cophuran robberfly (endemic to the site and last seen in 1939 and presumed extinct), Antioch efferian robberfly, Antioch adrenid bee, Antioch mutillid wasp (possibly extinct), Middlekauff's shieldback katydid, Suisun marsh aster, Delta tulle-pea, and Mason's lilaeopsis.<sup>6</sup>

In the early 2000s, a series of wildfires substantially decreased the butterfly population. In 2010, it was estimated that there were only around 100 butterflies—all on the refuge's 14-acre eastern unit. A turning point came in 2013 when the Port of Stockton, in collaboration with U.S. Army Corps of Engineers, began delivering sand to rebuild the dunes, benefitting the evening primrose, wallflower, Antioch Dunes buckwheat, and thus the Lange's metalmark butterfly. Eventually the refuge hopes to re-establish the Lange's butterfly on the western unit as well.

The refuge's partnership with California Wildlife Foundation, which began in the early 2000s, advances habitat restoration and endangered species recovery. The foundation is able to handle contracting with partners and manages mitigation and endowment funds for the recovery of the three endangered species. These funds cover invasive weed management, the restoration of host plants for the butterfly, and a biological technician who helps with weeding, planting, and monitoring for several months of the year. NRG Energy, Inc also contributes approximately \$25,000 annually for refuge maintenance costs.

The coexistence of endangered species and the heavy industry that surrounds Antioch Dunes presents ongoing challenges. For example, airborne gypsum from a nearby facility sometimes settles on the plants. Nevertheless, species are recovering. Future generations can enjoy and learn from Antioch Dunes evening primrose, Contra Costa wallflower, and Lange's metalmark butterfly thanks to scientific and conservation efforts that have been underway for over 150 years. The extirpation of other Antioch Dunes species is a reminder that protection of imperiled natural communities requires perseverance and collaboration.

<sup>1</sup> Thorne, KM et al., 2021. *Distribution, Abundance, and Genomic Diversity of the Endangered Antioch Dunes Evening Primrose ("Oenothera deltoides" subsp. "Howellii") Surveyed in 2019*. U.S. Geological Survey Open-File Report 2021-1017, [pubs.usgs.gov/publication/ofr20211017](https://pubs.usgs.gov/publication/ofr20211017). p.2.

<sup>2</sup> U.S. Fish and Wildlife Service. 2001. *Antioch Dunes National Wildlife Refuge Draft Comprehensive Conservation Plan and Environmental Assessment*. p. 23.

<sup>3</sup> *Ibid.* p. 7.

<sup>4</sup> *Ibid.* p. 9-10.

<sup>5</sup> U.S. Fish and Wildlife Service. *Dredging up the past at Antioch Dunes*. 2020. [fws.gov/story/2020-12/dredging-past-antioch-dunes](https://fws.gov/story/2020-12/dredging-past-antioch-dunes)

<sup>6</sup> *Supra* note 2. p. 27.

# Mending our fragmented landscapes: How the National Park Service is making the Santa Monica Mountains whole again

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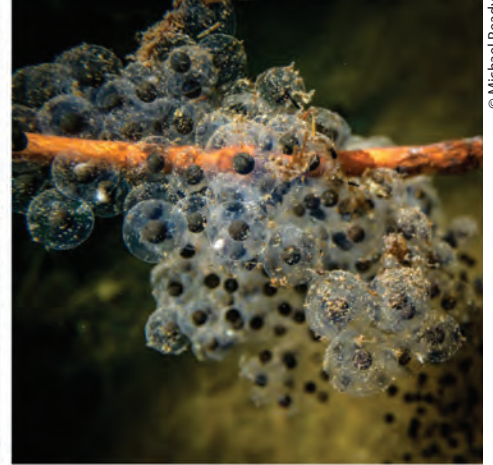
The Santa Monica Mountains contain one of the most amazing juxtapositions of wildland and urban landscapes in the world. Mountain lions (*Puma concolor*, Southern California evolutionarily significant unit, state threatened) cross 10 lane highways, bobcats roam in suburban communities, and coyotes are a daily occurrence in most neighborhoods. While it may seem like these species can survive this urban matrix on their own, they require the help of scientists, land managers, and the local community to thrive.

Highways, smaller roads, and urban communities fragment the mountains into small patches of habitat. Many species, especially larger ones, need bigger spaces to persist.

To overcome these challenges, staff at the Santa Monica Mountains National Recreation Area have employed multiple approaches, including the Wallis Annenberg Wildlife Crossing ([101wildlifecrossing.org/](http://101wildlifecrossing.org/)). Considered to be one of the most ambitious crossings ever constructed, it is over 300 feet in length and traverses 10 lanes of the busy 101 freeway. But the effort to reconnect landscapes also involves translocating endangered species into prime habitats, learning how wildlife move across the landscape, understanding the challenges they face, and reestablishing native plants in areas dominated by invasive species.

**Connecting:** While the Wallis Annenberg Wildlife Crossing will provide safe passage over a busy stretch of highway for many species, its value is more nuanced. It will increase gene flow of species in and out of the Santa Monica Mountains. Years of tracking data identified Liberty Canyon as the best possible location for a wildlife crossing. With genetic diversity of Santa Monica lions at an all-time low, this crossing addresses the root cause behind their genetic collapse and provides the population with a means to find mates in other areas beyond the Santa Monica Mountains.

**Tracking:** Understanding what wildlife need to thrive is complicated business. Animal movements are driven by access to water, food, cover, and mates. With data



Images from the Santa Monica Mountains (clockwise from upper left: An oak tree is planted as part of a landscape-scale restoration effort; a California red-legged frog egg mass dangles on a submerged plant; National Park Service biologist David Starzenski tracks a bobcat; the Wallis Annenberg Wildlife Crossing nearing completion).

from GPS-powered collars, biologists can understand when and where wildlife move, what they may be looking for, and what may be impeding them. This information helps biologists identify areas in need of greater protection and how to alleviate some of the barriers to movement.

**Translocating:** Some wildlife species don't have the ability to leave their home range in search of another more amenable one. Frogs, for example, are limited to the watershed in which they are born. If that watershed degrades, then the population will likely decline and possibly vanish. Urban development has led to stream degradation, which has caused California red-legged frogs (*Rana draytonii*, federally threatened) to disappear from many area streams. These frogs are not able to recolonize restored watersheds on their own. With an abundance of frogs living in a large, protected watershed, biologists have

been able to translocate small groups and their egg masses from the source population to streams that provide high-quality red-legged frog habitat. However, it's critical to understand and remove the threats that caused the frogs to become locally extirpated. Eliminating invasive predators and ensuring high water quality are critical factors that determine potential habitat.

**Mending:** Wildlife depend on vegetation in their native habitat. Urban development and increasing wildfire occurrences over the past 150 years have drastically altered the native vegetation that Santa Monica Mountains wildlife depend upon. The National Park Service is working to restore non-native dominated landscapes back to functional native habitats, with multiple nurseries producing more than 50,000 native plants each year. This final

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Sketch of National Park Service biologists searching for California red-legged frogs and their egg masses.

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piece of the management puzzle is perhaps the most important, as it provides the foundation upon which all of wildlife management is based. Without native resources in place, lions won't roam, frogs won't persist, and butterflies won't pollinate.

California Wildlife Foundation has been a steady partner across many of our projects. The foundation played a critical role in providing support to our science communication team while we delivered the field-effort and management. Our partnership ensures that the public is aware of the science and dedication required to manage this multifaceted effort across a complex landscape.

When you hear about the opening of the wildlife crossing (anticipated in December 2026), remember that there were, and continue to be, many steps to reconnecting the landscapes of the Santa Monica Mountains.

## In Memoriam: Pauline Geisler



Pauline was an avid photographer and captured thousands of images for use by Cabrillo National Monument.

Pauline Geisler, a respected and beloved tidepool educator at Cabrillo National Monument, passed away on March 5, 2026, at the age of 61. She served first as a volunteer along with her father, and then as a member of the staff. She led a team of 80 Tidepool Protection, Education, and Restoration Program volunteers for over 8 years. Working most recently under a cooperative agreement between National Park Service and California Wildlife Foundation, Pauline's legacy was protecting the park's wondrous yet fragile tidepools, educating visitors about how to explore them responsibly and safely, organizing tidepool cleanups, and providing unwavering volunteer support and appreciation. Her sense of humor, congenial personality, leadership, organizational skills, and care for tidepools leave a lasting impact on the park, its visitors, and those who worked alongside her.

## How you can help:

- Donate to California Wildlife Foundation/California Oaks. A secure donation can be made from our website: [californiaoaks.org](http://californiaoaks.org)
- Spend time in an oak woodland or forest. Click on [californiaoaks.org/resources](http://californiaoaks.org/resources) for a partial listing of oak landscapes around the state that have public access.
- Consider including oak conservation in your financial and estate planning efforts. Information can be found at: [californiaoaks.org/donate](http://californiaoaks.org/donate)
- Be vigilant about threats to oak woodlands and oak-forested lands in your community and consult [californiaoaks.org](http://californiaoaks.org) for guidance.
- Avoid spreading oak pests and pathogens. Consult the Resources column on page 3 and the Further Resources (page 4) from the cover article for information.
- Restore oaks to areas where they historically grew.
- Sign up for the *Oaks* e-newsletter at [californiaoaks.org](http://californiaoaks.org)
- Support local and statewide measures to protect natural resources.
- Hold decision-makers accountable for protecting green infrastructure.
- Learn about and support Indigenous stewardship of oak ecosystems.

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*Latin names are used for species with designated state or federal endangered or threatened species status. They are also used more broadly in the cover article.*

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