Conservation Gap Analysis of Native U.S. Oaks

Species profile: ***Quercus pacifica***

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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

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Quercus pacifica Nixon & C.H.Müll.

Synonyms: *Quercus dumosa* var. *polycarpa* Greene **Common Names:** Island scrub oak, Channel Island scrub oak, Pacific oak

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Zoya Akulova

DISTRIBUTION AND ECOLOGY

Quercus pacifica, or Island scrub oak, is endemic to three of the California Channel Islands, U.S.: Santa Cruz, Santa Catalina, and Santa Rosa. The species is not present on the California mainland, but did previously bear the name *Quercus dumosa*, as was applied to a few shrub oaks in the "*Q. dumosa* complex." At least five taxa within this complex are now recognized as distinct species, based on acorn morphology, leaf vestiture, and habitat. *Quercus pacifica* occurs from 0 to 700 meters above sea level, and grows most often as a shrub reaching two meters tall, but can also appear in a small tree form, five or more meters. This species is the dominant component of Island scrub oak chaparral, covering a variety of surfaces including ridges, open slopes, and canyons.[1] Also present in oak woodland, grassland margins, and closed-pine understory, this species is mainly limited by its occurrence on only three islands, rather than a need for very specialized habitat. Trees mature at about 40 years of age, and live up to 100 years or longer.[2]

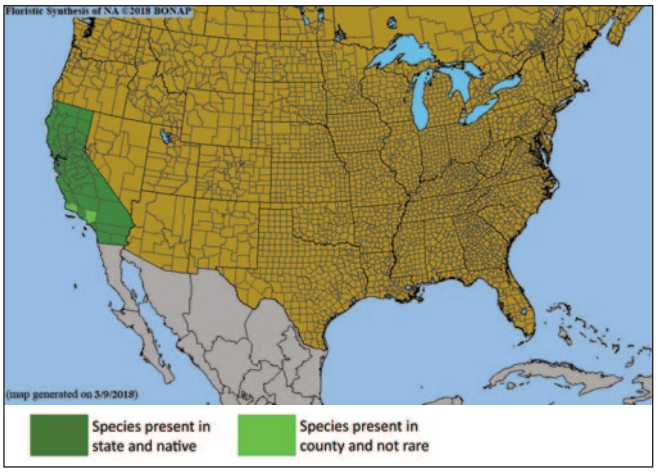

Figure 1. County-level distribution map for *Quercus pacifica*. Source: Biota of North America Program (BONAP).[3]

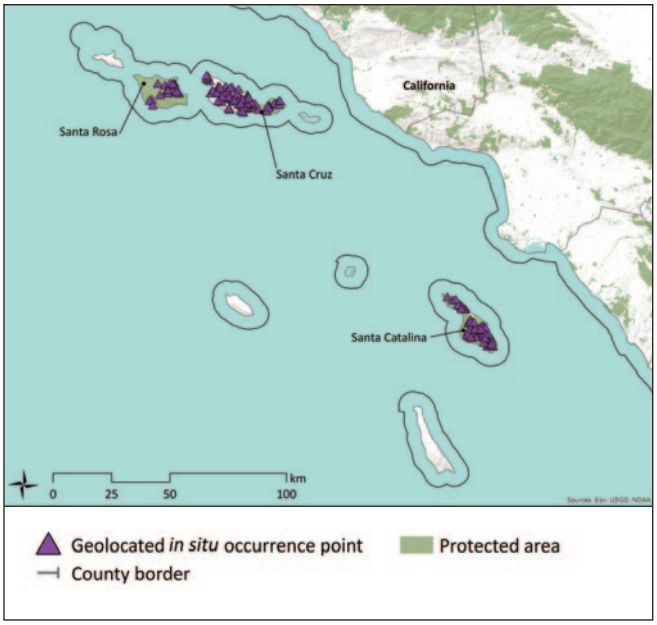

Figure 2. Documented *in situ* occurrence points for *Quercus pacifica*. Protected areas layer from U.S. Geological Survey Gap Analysis Program (GAP) 2016 Protected Areas Database of the U.S. (PAD-US).[4]

VULNERABILITY OF WILD POPULATIONS

Table 1. Scoring matrix identifying the most severe demographic issues affecting *Quercus pacifica*. 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	0
Range/endemism	Extremely small range or 1 location	EOO < 100 km^2 or AOO < 10 km^2 or 2-4 locations	EOO < 5,000 km^2 or AOO < 500 km^2 or 5-9 locations	EOO < 20,000 km^2 or AOO < 2,000 km^2 or 10+ locations	EOO > 20,000 km^2 or AOO > 2,000 km^2	Unknown	20
Population decline	Extreme	>= 80% decline	>= 50% decline	>= 30% decline	None	Unknown	5
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	0
						Average vulnerability score	8.3
						Rank relative to all U.S. oak species of concern (out of 19)	11

THREATS TO WILD POPULATIONS

High Impact Threats

Human Use of Landscape - e.g. agriculture, ranching, grazing, silviculture: Ranching and subsequent decimation by introduced herbivores (feral pigs, goats, sheep) occurred for more than a century on all of the Channel Islands. Feral goats and pigs were removed from Santa Catalina Island by the Catalina Island Conservancy in the early 2000s.[5] The Nature Conservancy successfully eradicated feral sheep from 90% of Santa Cruz Island by 1988 and pigs by 2008.[6,7] Sheep and cattle were removed from Santa Rosa Island by 1998, however remaining trees struggled to reproduce in the dry, eroding soils that are no longer sheltered by a shrub layer.[8,9] Past wood harvesting could have also decimated large areas of oak habitat on all three islands.

Moderate Impact Threats

Human Modification of Landscape - e.g. fire and fire suppression, eradication, pollution: Air pollution has the potential strain *Q. pacifica* stands, but fire regime alteration is known to stress Santa Catalina Island's native ecosystem. On the Island, "fire is a natural disturbance...however, high fire frequency can eliminate woody plants and cause a type conversion to non-native annual grassland."[11,12] Pond core samples from Santa Rosa Island suggest that fire frequency was generally low before human arrival and likely increased due to active habitat management by Chumash Native Americans.[9,13] Natural ignition rates are thought to be relatively low in coastal areas.[14]

Human Modification of Landscape - e.g. invasive species competition: Non-native annual grasses likely contribute to reduced acorn germination and survival of oak seedlings through a combination of competition, nutrient cycling shifts, insect facilitation, and disturbance regime alteration on the Channel Islands; experiments utilizing prescribed burning or mechanical removal of invasive plants are necessary to confirm these hypotheses. Burns may prove difficult though, since the grasses seem to "act as ladder fuels, carrying fire into the canopy of oaks."[2,5] On Santa Cruz Island, non-native fennel (*Phoeniculus vulgare*) has spread extensively, particularly after the removal of pigs.[15,16,17] Non-native black-tailed deer have recently achieved record densities on Santa Rosa Island, and *Q. pacifica* leaves form an integral part of their diet. Oak seedlings were also found to be strongly affected by physical destruction and trampling by non-native bison (*Bos bison*).[18]

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 (Figure 3). 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 5).

Results of 2017 *ex situ* survey	
Number of *ex situ* collections reporting this species:	11
Number of plants in *ex situ* collections:	80
Average number of plants per institution:	7
Percent of *ex situ* plants of wild origin:	85%
Percent of wild origin plants with known locality:	96%

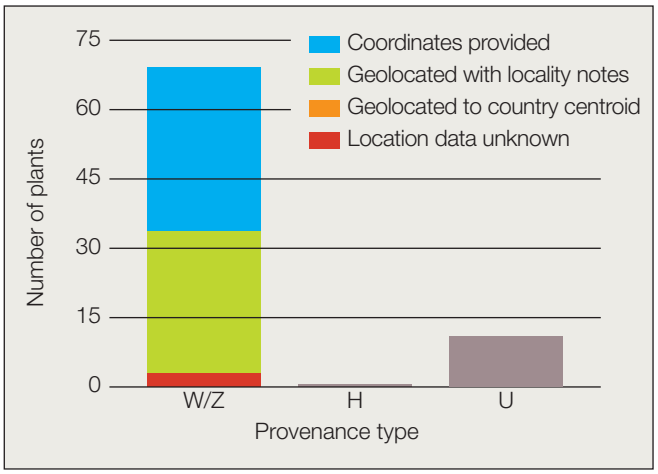

Figure 3. Number and origin of *Quercus pacifica* plants in *ex situ* collections. Provenance types: W = wild; Z = indirect wild; H = horticultural; U = unknown.

A spatial analysis was conducted to estimate the geographic and ecological coverage of *ex situ* collections (Figure 4). 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:	67%
Ecological coverage:	100%

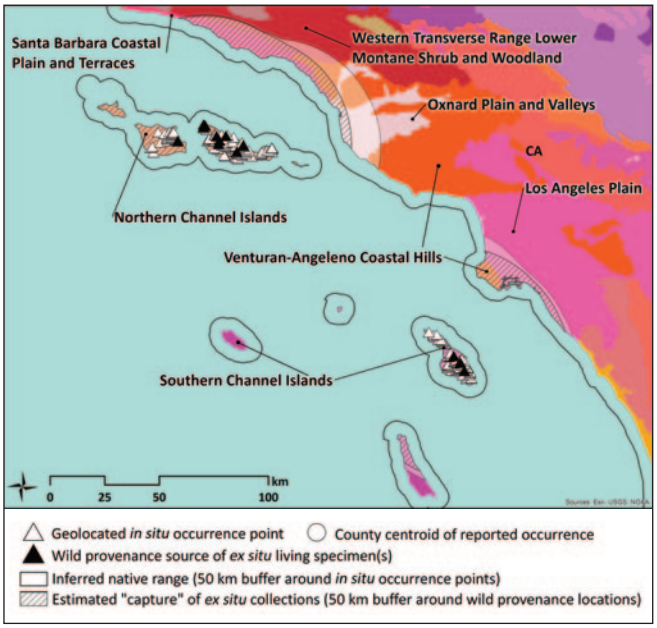

Figure 4. *Quercus pacifica in situ* occurrence points and *ex situ* collection source localities. U.S. EPA Level IV Ecoregions are colored and labelled.[22] County centroid is shown if no precise locality data exist for that county of occurrence. Email treeconservation@mortonarb.org for information regarding specific coordinates.

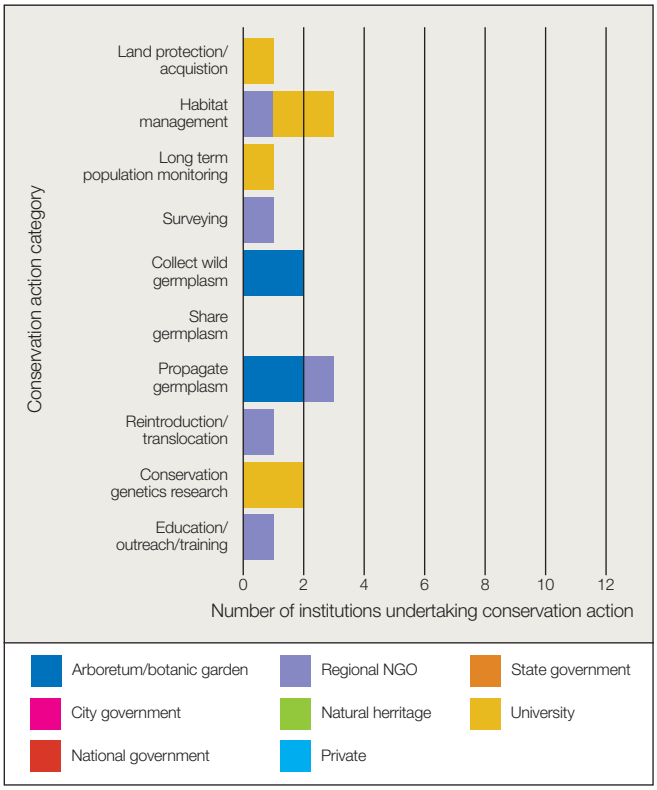

Figure 5. Number of institutions reporting conservation activities for *Quercus pacifica* grouped by organization type. Six of 252 institutions reported activities focused on *Q. pacifica* (see Appendix D for a list of all responding institutions).

Land protection: Within the inferred native range of *Q. pacifica*, 46% of the land is covered by protected areas (Figure 6). However, because this species' distribution is small and well-documented, we know that nearly 100% of the species' potential occurrences within the U.S. are within protected areas.

The Catalina Island Conservancy owns and manages 88% of the Island, The National Park Service owns all of Santa Rosa Island and the eastern 24% of Santa Cruz Island, and The Nature Conservancy owns the remaining 76% of Santa Cruz Island. Little protection has been necessary on Santa Rosa and Santa Cruz following the removal of non-native ungulates.[19,23] Island scrub oak groves that burned during the 1999 Goat Harbor fire on Santa Catalina Island were fenced due to decimation of basal sprouts by deer.[11]

Sustainable management of land: The Catalina Island Conservancy has developed and implemented a comprehensive management program for the Island, entitled Catalina Habitat Improvement and Restoration Program (CHIRP). The Conservancy uses both chemical and manual techniques for removing invasive plants, which began with "mapping of all manageable invaders then eradication of high-impact, low-abundance species and control of high-impact, high-abundance taxa in priority areas;" preventative treatment along dispersal corridors is also a high priority.[5,24] A draft fire management plan was created for Santa Catalina Island in 2003, but "the mosaic rotational burning may not be appropriate for the habitat types and conditions on Catalina Island."[5]

Since the removal of non-native livestock led to a rebound of Island scrub oak on Santa Cruz, many hope that the other two islands will soon recover as well.[2] However, a recent study simulated the observed oak habitat recovery on Santa Cruz and suggests that the absence of seed dispersal by birds has a stifling effect on the spatial extent of recovery, as movement by gravity only allows recovery of areas down-hill from current stands.[10] A potential management for Santa Rosa Island therefore includes the reintroduction of the recently-extinct Island scrub-jay (*Aphelocoma insularis*).[7]

Population monitoring and/or occurrence surveys: Within-stand densities, tree sizes, and acorn production of *Q. pacifica* populations on all three islands of occurrence have recently been surveyed, and subpopulations on Santa Cruz Island are experiencing a strong recovery from past decline.[21] Long-standing vegetation monitoring has also been in place, such as a study between 1984 and 2005 on Santa Cruz Island, which observed the response of endemic plant species to the eradication of feral sheep.[6] Recent studies have found that passive recovery of Santa Cruz Island has resulted in an increase of woody vegetation overstory from 27% to 53%, yet a decline in oak cover on their transects was recorded between 1980 and 2012.[25] Because *Q. pacifica* is a late-successional species, however, the effects of herbivore removal will likely take time to affect oak distributions.

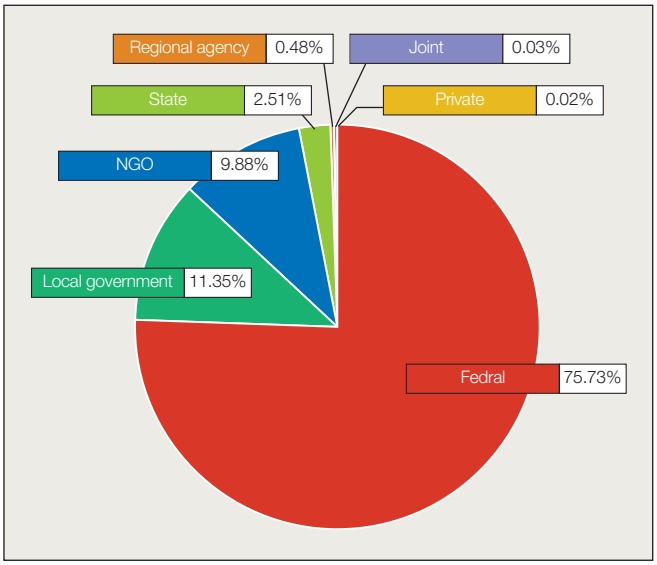

Figure 6. Management type of protected areas within the inferred native range of *Quercus pacifica*. Protected areas data from the U.S. Geological Survey Gap Analysis Program (GAP) 2016 Protected Areas Database of the U.S. (PAD-US).[4]


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Based on remote-sensing data of vegetation patterns, spatial autocorrelation of woody vegetation in the landscape is likely a consequence of seed dispersal by Island scrub-jays and Island foxes (*Urocyon littoralis santacruzae*).[26] An ongoing long-term study (Santa Cruz: 2008 – current; Santa Rosa: 2012 – current) of ~400 *Q. pacifica* individuals is tracking growth, survival, and seed production; the data suggest low mortality of adults (M. Pesendorfer, unpublished data).[21] The Santa Catalina Conservancy also closely monitors populations of *Q. pacifica* on the Island.[12]

Wild collecting and/or *ex situ* curation: Two institutions reported this activity in the conservation action questionnaire, but no other details are currently known.

Propagation and/or breeding programs: The Catalina Island Conservancy has participated in active restoration of *Q. pacifica* habitat, including propagation and planting of young oaks; this initiative began with a pilot monitoring study in 2001. Another project, this time focused on Santa Cruz Island, recently planted over 600 acorns within a greenhouse to determine the possible role of acorn size in *Q. pacifica* regeneration.[27] *Quercus pacifica* is available for public purchase at Ackerman Native Plant Nursery.[28]

Reintroduction, reinforcement, and/or translocation: Subpopulations on Santa Cruz Island have experienced a strong recovery from past decline, but the subpopulations on Santa Rosa and Santa Catalina islands are still of conservation concern, with active management occurring through acorn planting in disturbed oak habitat.[27] Following a 258-acre fire on Santa Cruz Island in March 2018, Pesendorfer and colleagues have initiated restoration trials aimed to increase acorn hoarding by Island scrub-jays in target areas along the fire perimeter (M. Pesendorfer pers. comm., 2018).

Research: Many research initiatives exist for species and ecosystems on the California Channel Islands; the following paragraphs give a sample of these activities.

Backs & Ashley (2016) took samples from all three islands where *Q. pacifica* is found and assessed their genetic makeup: "Genetic differentiation of *Q. pacifica* among islands is small but significant. Both recent and historical gene flow were surprisingly high considering the disjunct distribution of *Q. pacifica* on islands separated by as much as 125 km of open ocean...We found no evidence for recent bottlenecks, suggesting that the overgrazing and vegetation loss of the 20th century did not have a negative genetic impact on *Q. pacifica*. We did find evidence that bottlenecks took place at some time in the past, perhaps associated with the original colonization of the islands."[30]

Pesendorfer *et al*. (2014) "sampled within-stand densities, tree sizes, and acorns in 3 island populations that have been exposed to different herbivores, seed predators, and climate conditions" on Santa Cruz Island. Findings revealed that "trees at higher elevations produced more acorns, but the roles of temperature and precipitation were unclear." Long-term monitoring across the California Channel Islands would be necessary to better understand the acorn production drivers for *Q. pacifica*.[21] A subsequent study found that "larger acorns are more likely to germinate," and "acorn mass had strong effects on root mass, shoot mass, seedling height and leaf surface area." Therefore, they suggest that managers plant larger acorns within restoration projects.[27] Klinger *et al*. (2002) also studied Santa Cruz Island, focusing on the complex effects of removing non-native grazers (e.g., goats, cheep, cows): "It is often assumed that removing nonnative grazers from islands will lead to recovery of native specie. This assumption can be justified to a certain degree, but as a general expectation it is probably overly simplistic. As the patterns showed on [Santa Cruz Island], removing feral animals from islands will lead to a range of complex effects, many of which will be beneficial to native species and many of which may not."[6]

In 2001 a pilot study was conducted by Catalina Island Conservancy, which mapped oak individuals in eight 30 by 6 meter transects; data gathered included age class, number of stems/trunks, basal diameter of the largest three trunks, overall health, acorn production, and animal/pest damage. Half of the transects were located on the western end of the Island, where all feral animals except deer have been removed since the mid to late 1990's, and the other half were in the north-central portion of the Island where non-native animal removal has been more recent. The study found an average 26% of trees in each transect to be dead, saplings within only two of the eight transects, and seedlings in three of the eight transects. Acorns were seldom found, though many trees were ranked as having good or very good overall health; but no trees were ranked as excellent.[29]

In partnership with the National Park Service, Dr. McEachern and colleagues are studying the cloud forest recovery on Santa Rosa Island, which includes stands of Island scrub oak. They are utilizing "artificial structures to slow erosion, capture fog, increase soil moisture and establish plants from nursery-grown stock and seeds. The project's long-term goals are to create self-sustaining stands of trees and shrubs that can re-start the upland hydrologic cycle, and demonstrate the local effects of fog on plant growth, soil moisture, erosion rates, sustainability and ecological complexity."[31]


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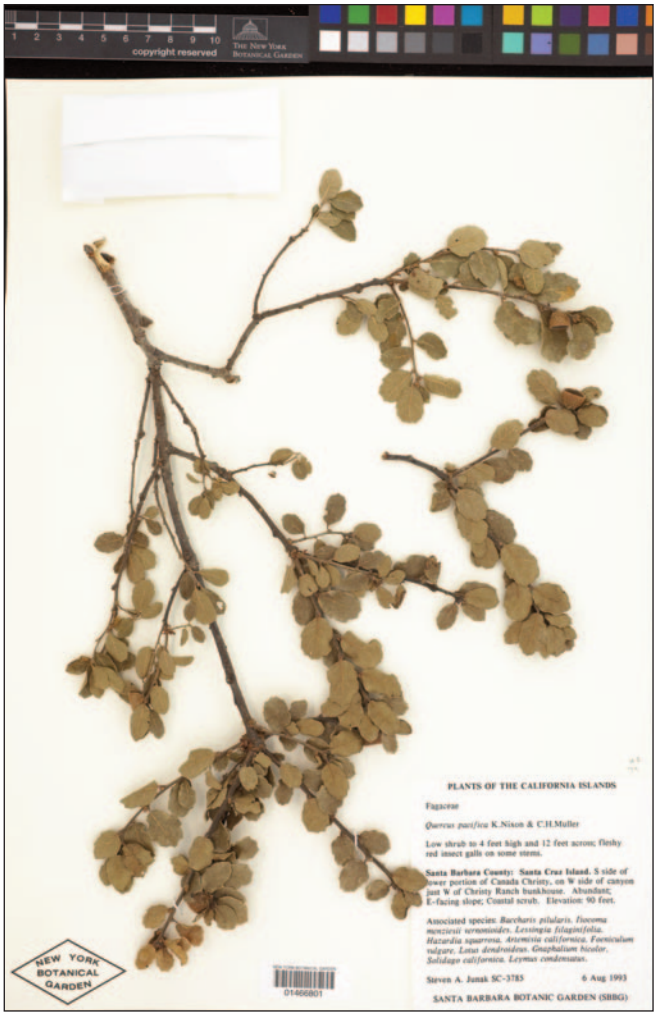
Education, outreach, and/or training: A description of *Q. pacifica* care and uses within gardens and patios is available online at learn2grow.com. It has also been pointed out that, "some of the Island's constraints are also key assets. The high level of visitation to Santa Catalina makes it an ideal educational and outreach center. The Conservancy's Nature Center and Botanical Garden are perfect venues to educate about the uniqueness of the islands, the threats that face them, and the benefits of restoration."[24] In collaboration with UC Santa Barbara's Office of Education Partnerships, Pesendorfer and Sillett have initiated annual conservation experience workshops, which introduce undergraduate students from underrepresented minority background to basic techniques of field ecology. In addition, students from the Smithsonian Scholars Program have been conducting oak restoration trials in the 2018 fire scar (M. Pesendorfer pers. comm., 2018).

Species protection policies: No known initiatives at the time of publication.



PRIORITY CONSERVATION ACTIONS

While Island scrub oak has received more attention from managers and scientists than other western North American scrub oak species, there are substantial gaps in our understanding; these gaps include population dynamics and regeneration across its range, potential vulnerabilities to changes in abiotic conditions and threats from non-native pests, as well as effective management tools to ensure the long-term persistence of the species. Specifically, research and management efforts would benefit from coordination across institutions and populations, so that biotic and abiotic drivers of die-off and recruitment can be identified. Annual oak surveys should be incorporated into a long-term monitoring program across the California Channel Islands. Such information would be crucial to project potential impacts of changes in temperature and precipitation, and to gain a better understanding of *Q. pacifica* acorn production drivers. Furthermore, in light of potential threats by non-native pests such as the goldspotted oak borer (*Agrilus coxalis*), which has devastated *Q. agrifolia* population in southern California, systematic exposure trials of mainland individuals could provide insights that could prevent large-scale mortality. These research activities will play an important role in continuing to develop effective land management plans for the islands.

In addition, wild germplasm should be gathered from population not yet represented in *ex situ* collections, for long-term preservation as living specimens in gardens and arboreta globally. A coordinated effort of managers to develop protocols for cost-effective restoration and propagation techniques should also be carried out. This will allow for landscape-scale management, particularly in areas where non-native plant populations are currently being removed or combatted (e.g., Eucalyptus groves on Santa Cruz Island).

Conservation recommendations for *Quercus pacifica*

Highest Priority

- Population monitoring and/or occurrence surveys
- Research (pests/pathogens; reproductive biology/regeneration; restoration protocols/guidelines)
- Wild collecting and/or *ex situ* curation

Recommended

- Propagation and/or breeding programs
- Reintroduction, reinforcement, and/or translocation
- Sustainable management of land

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