Conservation Gap Analysis of Native

Mesoamerican Oaks


Francisco Garin

Species profile: ***Quercus costaricensis***

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CRITICALLY ENDANGERED

Quercus graciliformis
Quercus mulleri

ENDANGERED

Quercus brandegeei
Quercus carmenensis
Quercus cualensis
Quercus cupreata
Quercus delgadoana
Quercus devia
Quercus diversifolia
Quercus dumosa
Quercus engelmannii
Quercus flocculenta
Quercus galeanensis
Quercus hintonii
Quercus hirtifolia
Quercus insignis
Quercus macdougallii
Quercus miquihuanensis
Quercus nixoniana
Quercus radiata
Quercus runcinatifolia
Quercus tomentella

VULNERABLE

Quercus acutifolia
Quercus ajoensis
Quercus cedrosensis
Quercus costaricensis
Quercus gulielmi-treleasei
Quercus hintoniorum
Quercus meavei
Quercus rubramenta
Quercus tuitensis
Quercus vicentensis

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Global Conservation Consortium Oak
CSS TREES Center for Species Survival
Fondation Franklinia

Quercus costaricensis Liebm.

Common Names, Spanish: Roble Negro
IUCN Red List Status: Vulnerable: A2cd; B1ab(ii,iii)+2ab(ii,iii)

Species profile expert: Luis G. Acosta-Vargas, Instituto Tecnológico de Costa Rica

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DISTRIBUTION AND BIOLOGY

Quercus costaricensis is distributed in Costa Rica and just over the border into western Panama (Figure 1). This species inhabits upper montane forests and paramo ecosystems, often in association with *Q. bumelioides*. Of all oak species in Costa Rica, *Q. costaricensis* grows at the highest altitude and is typically found at elevations between 2,300–3,600 m asl (Kappelle 2006; Morales, 2010). It occurs along both slopes of the Costa Rica Central Cordillera and the Cordillera de Talamanca (Morales, 2010). *Quercus costaricensis* has been observed in five Holdridge life zones, with a majority of known occurrences in cool temperate rain forest (Figure 2).

Quercus costaricensis is a medium to large evergreen tree, 3–50 m, in section Lobatae. At altitudes above 3,000 m, *Q. costaricensis* is typically smaller (< 25 m) and with twisted branches and dense, small leaves (Kappelle, 2006). This species is known for producing multi-seeded acorns, with one study finding 42% of *Q. costaricensis* acorns contain 2–4 seeds (Stevens and Matthew, 1989). *Quercus costaricensis* can be identified in part by its very dark, greenish-black bark. The leaves are dark green and leathery, elliptical to ovate in shape with entire margins, 10–15 cm long x 4–7 cm wide (Garin Garcia, 2021).

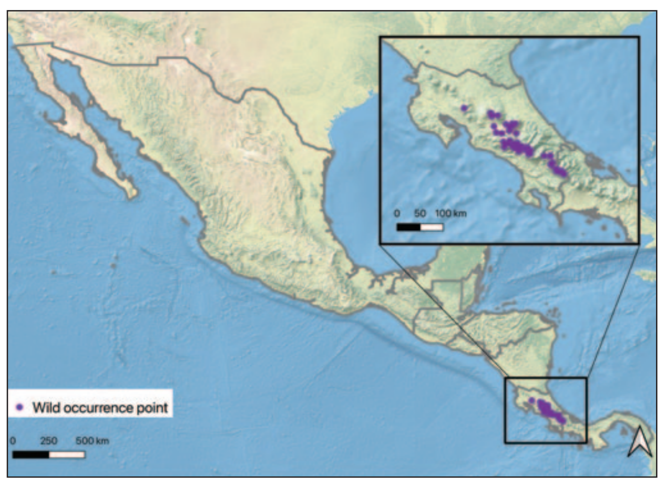

Figure 1. Wild (i.e., *in situ*) occurrence points for *Quercus costaricensis*.

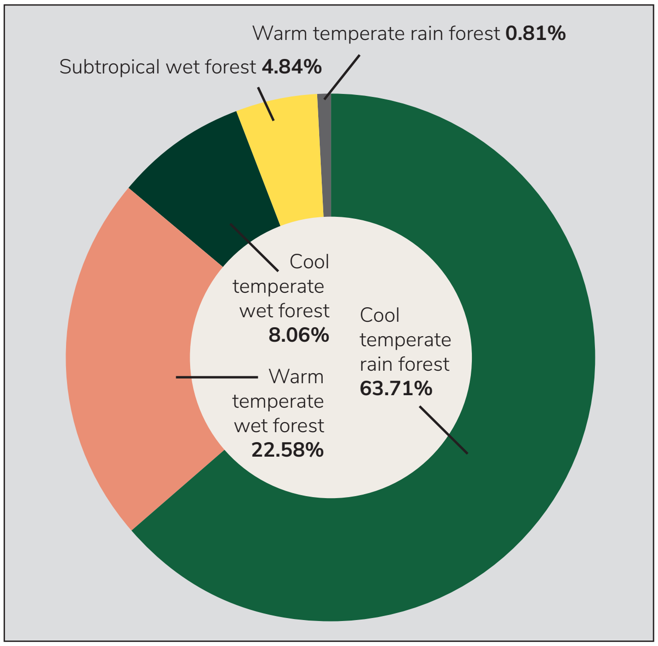

Figure 2. The percentage of wild occurrence points in each Holdridge life zone in which *Quercus costaricensis* is distributed.

THREATS TO WILD POPULATIONS

Human use of species — wild harvesting: *Quercus costaricensis* has historically been harvested for timber, firewood, and charcoal. This is not currently a major threat, since trees at lower elevations are primarily used instead (Kappelle et al., 2000).

Human use of landscape — agriculture, silviculture, ranching, and/or grazing: The steep slopes, remoteness, and relatively cool climate have limited the impact of agriculture within the mountainous regions of Costa Rica and Panama, and overall the region is well protected (Powell et al., 2018). The clearing of forest for agriculture is a potential threat in unprotected areas. However, since the range of this species is almost entirely protected, this is not currently considered a major threat.

Human use of landscape — residential/commercial development, mining, and/or roads: In 1943, the Inter-American highway was completed. This highway crosses the Talamanca mountain range at an altitude up to 3,300 m and there was considerable deforestation during construction (Oostra et al., 2008). That deforestation has since decreased considerably, and is not currently considered a threat.

Human use of landscape — tourism and/or recreation: This is not currently considered a threat.

Human modification of natural systems: Altered fire regime, pollution, eradication: Anthropogenic wildfires are one of the greatest threats to *Q. costaricensis* (Alvarez-Clare et al., 2020). Fires are common within paramo ecosystems, mainly to manage livestock, and the productivity of native vegetation tends to decrease following fire (Vega Mena and Rodríguez Solano, 2018). Within the species' native range in the Chirripo area of La Amistad National Park, more than 4,000 ha of oak forest were burned in the years 1975–2005 (Esquivel-Garrote, 2010). In 1992 there was a fire in Cerro Asunción that impacted approximately 40 hectares (Vega Mena and Rodríguez Solano, 2018), and there are also reports of several fires in Irazú Volcano National Park within the last six years. Although small, these first have high potential to impact *Q. costaricensis* with the park.

Human modification of natural systems — invasive species competition/disturbance: There is ongoing research on an invasive beetle (family Curculionidae) that impacts the oaks in the region, including *Q. costaricensis*.

Climate change — habitat shifting, drought, temperature extremes, and/or flooding: The montane cloud forest habitat of *Q. costaricensis* is expected to experience significant losses due to climate change (Ponce-Reyes et al., 2012). *Quercus costaricensis* is a high-elevation species and is especially vulnerable to a changing climate. Within the inferred native range of *Q. costaricensis*, the cool temperate rainforest is expected to decrease in area by an average of 67% by the years 2061–2080 relative to current conditions (Good et al., 2024). Similar results were found using ecological niche modeling to predict the change in *Q. costaricensis* habitat area as a result of climate change in the years 2050–2070. The authors found that *Q. costaricensis* decreased in area relative to current conditions in all model projections, ranging from -5.48% to -55.5%, depending on the representative concentration pathway used (Quesada-Quirós et al., 2016).

Genetic material loss — inbreeding and/or introgression: Unknown.

Pests and/or pathogens: *Quercus costaricensis* is affected by Lepidoptera in Irazú Volcano National Park.

Extremely small and/or restricted population: This is not considered a major threat as populations tend to be large in size. However, some populations may be isolated from each other. For example, due to deforestation and the presence of natural barriers such as the Cartago valley, the populations of the Poás and Irazú Volcano are isolated from the populations of the Cerro de la Muerte and Chirrpó National Park.

CONSERVATION ACTIVITIES

Once per year between 2017 and 2022, *Quercus* accessions data were requested from *ex situ* collections globally. A total of 197 institutions from 27 countries submitted data for Mesoamerican oak species, including *Q. costaricensis* (Table 1, Figure 3). Past, present, and planned conservation activities for Mesoamerican oak species of concern were also examined through literature review and expert consultation.

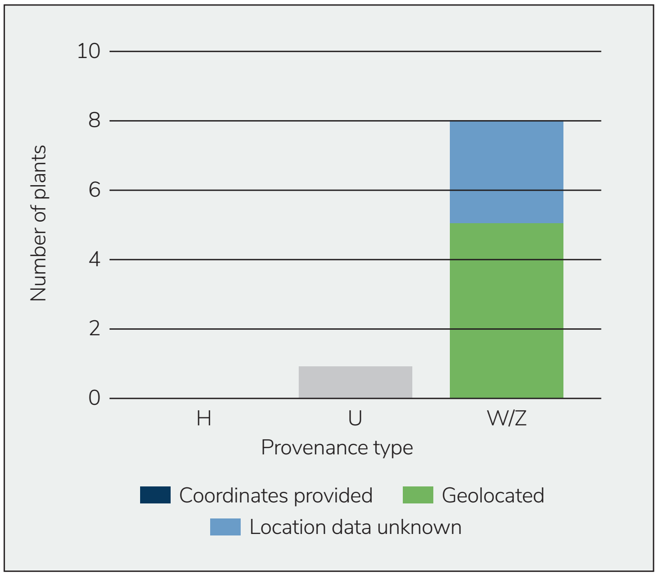

Figure 3. Number and origin of *Quercus costaricensis* plants in *ex situ* collections. Provenance types: H = horticultural; U = unknown; W = wild; Z = propagated from wild.

Table 1. Results of 2017–2022 *ex situ* surveys.

Number of *ex situ* collections reporting this species	3
Number of plants in *ex situ* collections	9
Average number of plants per institution	3
Percent of *ex situ* plants of wild origin	89%
Percent of wild origin plants with known locality	63%

A spatial analysis was conducted to estimate the geographic and ecological coverage of *ex situ* collections using methods adapted from Khoury et al. (2020; Figure 4). Twenty-kilometer buffers were placed around each wild occurrence point as well as the source locality of each plant living in *ex situ* collections. Collectively, the buffer area around the wild occurrence points represents the inferred native range of the species. The buffer area around *ex situ* points serves as the native range represented in *ex situ* collections. Geographic coverage of *ex situ* collections was estimated by dividing the *ex situ* buffer area by the area of the inferred native range. Ecological coverage of *ex situ* collections was estimated by dividing the number of Holdridge life zones present under the *ex situ* buffer by the number of Holdridge life zones under the inferred native range. The species representativeness *ex situ* was calculated by counting the number of *ex situ* institutions that currently have one or more living individuals of wild provenance in their collections, up to a maximum of ten. In order to maintain a consistent scale across all scores, this number was multiplied by ten. All three scores range from 0–100. A final *ex situ* conservation score was calculated by taking an average of the three scores above. Final scores range from 0–100, with scores near 100 indicating comprehensive *ex situ* conservation, and scores near 0 indicating poor *ex situ* conservation (Table 2). As a reference, the threatened Mesoamerican oaks with the highest *ex situ* conservation scores are *Q. engelmannii* with a score of 76/100, and *Q. brandegeei* with a score of 74/100. There are 10 threatened oaks with final *ex situ* scores of 10 or less.

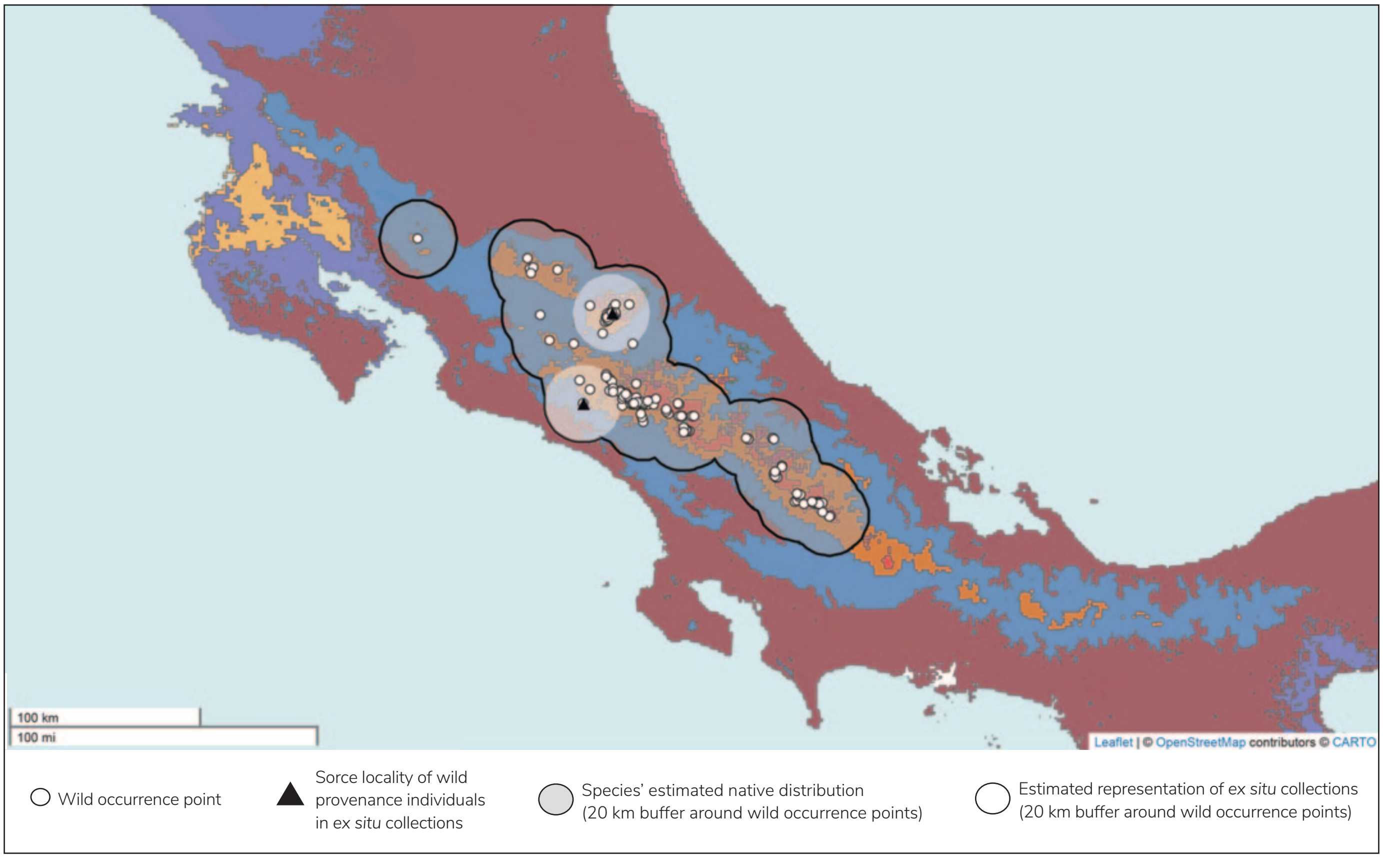

Figure 4. *Quercus costaricensis* wild occurrence points and ex *situ* collection source localities. Colored regions are Holdridge life zones. All ex *situ* collection source localities are also wild occurrence points.

Table 2. *Ex situ* conservation scores for *Quercus costaricensis* with all scores ranging from 0–100. A final score of 100 indicates comprehensive ex *situ* conservation, and a score of 0 represents poor ex *situ* conservation.

Geographic coverage ex *situ*	17
Ecological coverage ex *situ*	82
Representation in ex *situ* collections	20
Final *ex situ* conservation score	40

Using methods adapted from Khoury et al. (2020), we estimated the degree of representation of Q. *costaricensis* in protected areas in order to identify *in situ* conservation gaps. Wild occurrence points were mapped and overlaid with protected areas from the World Database on Protected Areas (Figure 5; UNEP-WCMC and IUCN, 2023). A twenty-kilometer buffer was placed around each occurrence point to represent the species inferred native range. Geographic coverage *in situ* was estimated by calculating the proportion of a species inferred native range that is covered by protected areas. Ecological coverage *in situ* was estimated by identifying the Holdridge life zones in the inferred native range as well as the Holdridge life zones in protected areas within the inferred native range and calculating the percentage of life zones that are conserved in protected areas. Species coverage *in situ* was estimated by calculating the percentage of known occurrence points within the species inferred native range that fall inside protected areas. All three scores range from 0–100. A final conservation score *in situ* was calculated by taking an average of the three scores above. Final scores range from 0–100, with scores near 100 indicating comprehensive *in situ* conservation, and scores near 0 indicating poor *in situ* conservation (Table 3). As a reference, the threatened Mesoamerican oaks with the highest *in situ* conservation scores are Q. *carmenensis* with a score of 99/100, and Q. *costaricensis* with a score of 94/100. There are two threatened oaks with final in situ scores of 10 or less.

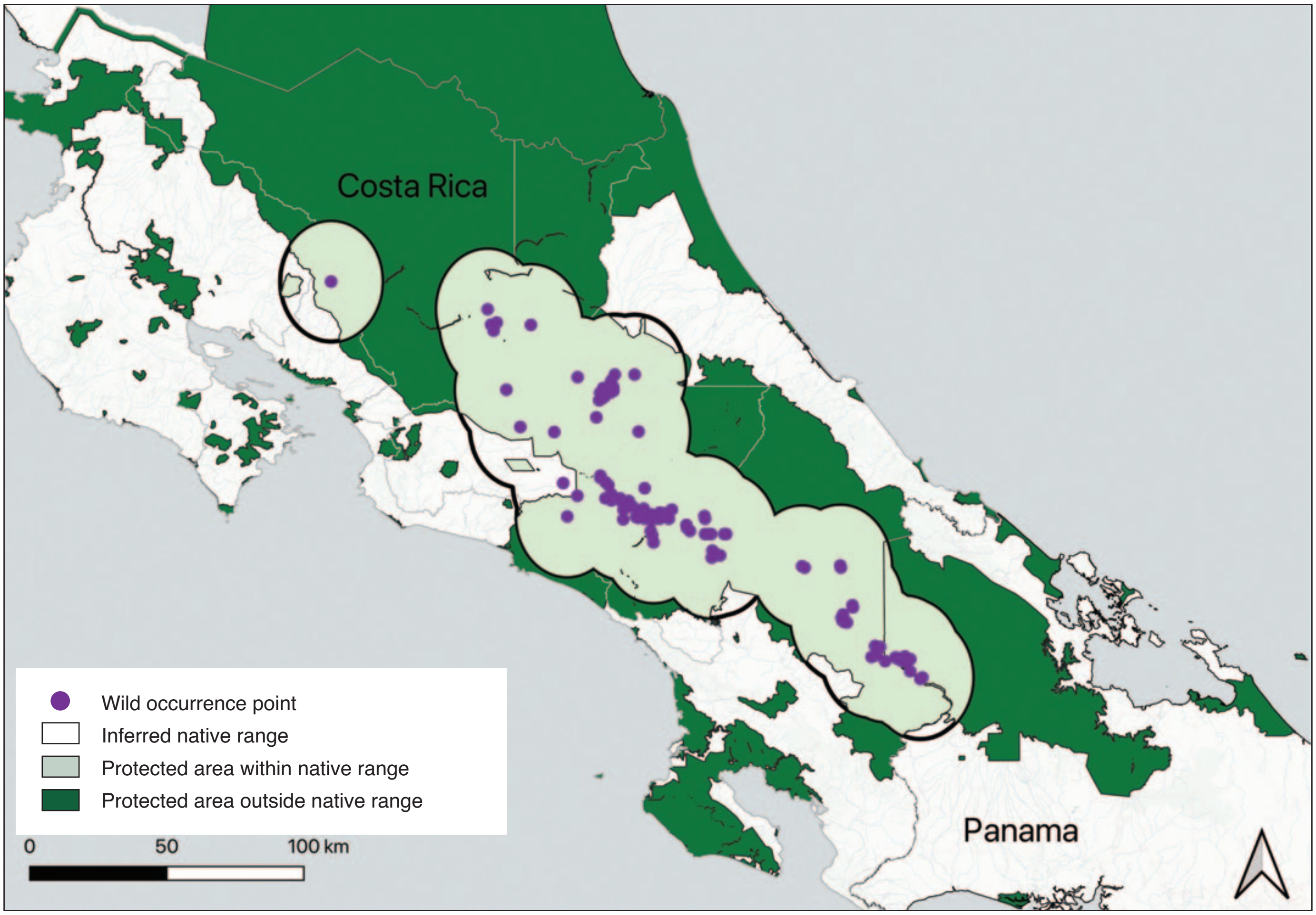

Figure 5. Wild occurrence points and inferred native range of *Quercus costaricensis* in relation to protected areas. Protected areas are from Protected Planet (UNEP-WCMC and IUCN, 2023.

Table 3. *In situ* conservation scores for *Quercus costaricensis* with all scores ranging from 0–100. A final score of 100 indicates comprehensive *in situ* conservation, and a score of 0 represents poor *in situ* conservation.

Geographic coverage *in situ*	91
Ecological coverage *in situ*	91
Species representation in *in situ* collections	99
Final *in situ* conservation score	94

Land protection: Within the species' inferred native range, 91% is on protected land (Figure 5). Important protected areas include the Turberas de Talamanca (Ramsar Site) in the southern portion of the species' range, and the Cordillera Volcánica Central (UNESCO-MAB Biosphere Reserve) in the north.

Sustainable management of land: There is a management plan for the Cordillera Volcánica Central protected area, with an emphasis on forest resource management and agroforestry systems.

Population monitoring and/or occurrence surveys: Specific monitoring for this species has not been done.

Wild collecting and/or ex *situ* curation: According to the results of our *ex situ* survey, this species is in three *ex situ* collections.

Propagation and/or breeding programs: There is a nursery in Parque Nacional Volcán Irazú established by The Costa Rica Institute of Technology (TEC) that has collected and germinated seeds of *Q. costaricensis*. This program is active as of the time of publication, although plant production is low.

Reintroduction, reinforcement, and/or translocation: Trees that were produced by the nursery in the Parque Nacional Irazú Volcanol were planted in the park following the completion of the project.

Research: There have been recent studies on genetic diversity (Rodríguez-Correa et al., 2018), germination and seedling morphology (Gutiérrez-Soto et al., 2021) and mycorrhizal fungal-tree-soil interactions (Holste et al., 2016) for *Q. costaricensis* specifically.

Education, outreach, and/or training: Unknown.

Species protection policies: There are currently no species protection policies for *Q. costaricensis*.

PRIORITY CONSERVATION ACTIONS

In order to conserve *Q. costaricensis*, the conservation activities that should be given the highest priority are:

Population monitoring and/or occurrence surveys

A population study is necessary to better understand if regeneration is occurring for this species, and to identify new occurrences of mature trees.

Propagation and/or breeding programs

Propagation of Q. costaricensis should be a priority, especially to support in situ conservation efforts.

Reintroduction, reinforcement, and/or translocation

Due to the vulnerability of Q. costaricensis to climate change, this species may benefit from assisted migration.

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