

# Conservation Gap Analysis of Native Mesoamerican Oaks



Béatrice Chassé

## Species profile: *Quercus carmenensis*

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### CRITICALLY ENDANGERED

*Quercus graciliformis*  
*Quercus mulleri*

### ENDANGERED

*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*



# *Quercus carmenensis* C.H.Müll.

Common Names, English: Mexican Oak

IUCN Red List Category and Criteria: Endangered: B1ab(iv)

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## DISTRIBUTION AND BIOLOGY

*Quercus carmenensis* is only known to exist in southwest Texas in the United States and in the Sierra del Carmen region in Coahuila, Mexico (Figure 1). It can be found at elevations of 2,000–2,500 m asl. This oak species thrives in mixed pine-oak forests as well as oak forest situated in elevated intermountain valleys and slopes with north and northwest exposures where there is more humidity. *Quercus carmenensis* coexists alongside a diverse array of flora including *Cupressus arizonica*, *Pseudotsuga menziesii*, *Pinus strobiformis*, *P. arizonica* var. *stormiae*, *Quercus*

*sideroxylla*, *Q. hypoleucoides*, *Q. rugosa*, *Q. gambelii*, *Garrya ovata*, *Salvia regla*, *Arbutus xalapensis*, *Arctostaphylos pungens*, *Acer grandidentatum* and *Juniperus* (Villarreal et al, 2008). A vast majority of *Q. carmenensis*' occurrences are within the warm temperate thorn scrub life zone (Figure 2). In 2023, an exploration was conducted to the Maderas del Carmen region in search of *Q. carmenensis*. The localities that have been explored within the Maderas region were “la cuesta de Malena” and “el cañón de la Media Luna” located between Muzquiz and Boquillas Municipalities. Although no individuals of *Q. carmenensis* were found during this expedition, other *Quercus* species were encountered such as *Q. hypoleucoides*, *Q. oblongifolia*, *Q. grisea*, and *Q. gravesii* among others. More botanical explorations are needed in order to find this rare oak species.

*Quercus carmenensis* is typically a rhizomatous shrub from 0.5 to 2 meters tall, but sometimes it can grow to be a small tree of 12 meters tall (Villarreal et al., 2008). Leaves are oblong to oblanceolate, 1–2 x 3–5 cm. The twigs and petioles of *Q. carmenensis* are typically red, which can be observed at a distance of 3–6 meters (Muller, 1937).

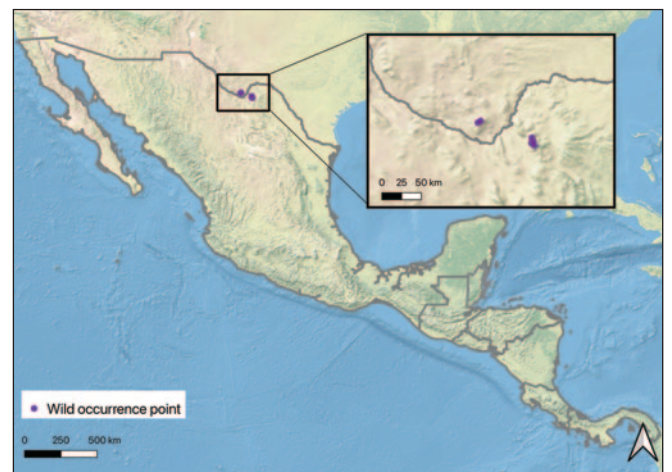
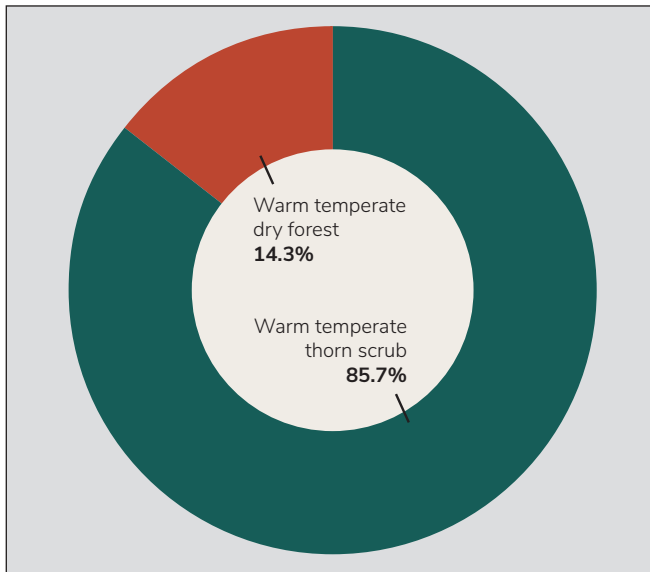


Figure 1. Wild (i.e., in situ) occurrence points for *Quercus carmenensis*.



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

## THREATS TO WILD POPULATIONS

**Human use of species — wild harvesting:** The Sierra del Carmen region is rich in oaks with an estimated 16 species. People have historically used oaks for firewood, but *Q. carmenensis* resides within a natural protected conservation site, the Sierra Maderas del Carmen. Additionally, CEMEX (a Mexican cement company) has purchased land for conservation in the region. Wild harvesting is not currently considered a threat.

**Human use of landscape — agriculture, silviculture, ranching, and/or grazing:** There is communal land used for agriculture and grazing by cows and horses within the boundaries of the Sierra del Carmen, potentially impacting new growth. However, this activity is low impact due to the small human population. In addition *Q. carmenensis* grows primarily in canyons that are less accessible to grazing animals. More research is needed on the potential impact of grazing on *Q. carmenensis*.

**Human use of landscape — residential/commercial development, mining, and/or roads:** This is not currently considered a threat. There is very little development within the native range of this species.

**Human use of landscape — tourism and/or recreation:** This is not currently considered a threat. There is a nature reserve for hunting animals within the area, but its low scale and permits are required for access.

**Human modification of natural systems — altered fire regime, pollution, eradication:** This is not currently considered a threat.

**Human modification of natural systems — invasive species competition/disturbance:** This is not currently considered a threat.

**Climate change — habitat shifting, drought, temperature extremes, and/or flooding:** *Quercus carmenensis* is prone to drought stress, and recently droughts within the region have become more extensive. The effects of prolonged drought should be studied over time. Within the inferred native range of *Q. carmenensis*, the warm temperate thorn scrub is expected to decrease in area by an average of 86% by the years 2061–2080 relative to current conditions (Good et al., 2024).

**Genetic material loss — inbreeding and/or introgression:** Hybridization with *Q. intricata* and *Q. grisea* has the potential to threaten the genetic integrity of *Q. carmenensis* (Kenny et al., 2016; Beckman et al., 2019).

**Pests and/or pathogens:** This is not currently considered a threat. However, the recent intense dry periods in the Maderas del Carmen region pose a potential risk. Such conditions can induce stress in *Q. carmenensis*, rendering it more susceptible to pests and pathogens.

**Extremely small and/or restricted population:** Over the years, various vegetation surveys have taken place in the Sierra del Carmen region, including a recent survey aimed at discovering new populations of *Q. carmenensis*. However, the observed *Quercus* individuals were identified belonging to different *Quercus* species, signifying the need for further botanical expeditions to pinpoint new populations accurately. The limited range of this species presents a significant threat to its survival, as only a few individuals have been identified over the past three decades.



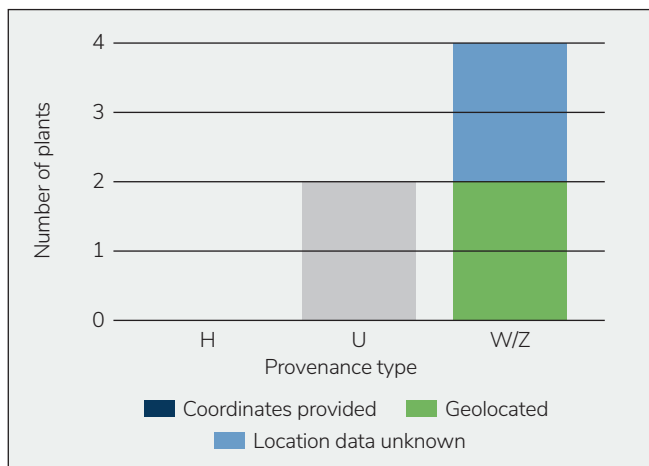
## CONSERVATION ACTIVITIES

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. carmenensis* (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.

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

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

Number of ex situ collections reporting this species	4
Number of plants in ex situ collections	6
Average number of plants per institution	2
Percent of ex situ plants of wild origin	67%
Percent of wild origin plants with known locality	50%



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

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.

Using methods adapted from Khoury et al. (2020), we estimated the degree of representation of *Q. carmenensis* 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 representativeness 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.

**Table 2.** Ex situ conservation scores for *Quercus carmenensis* 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	39
Ecological coverage ex situ	100
Representation in ex situ collections	20
Final ex situ conservation score	53

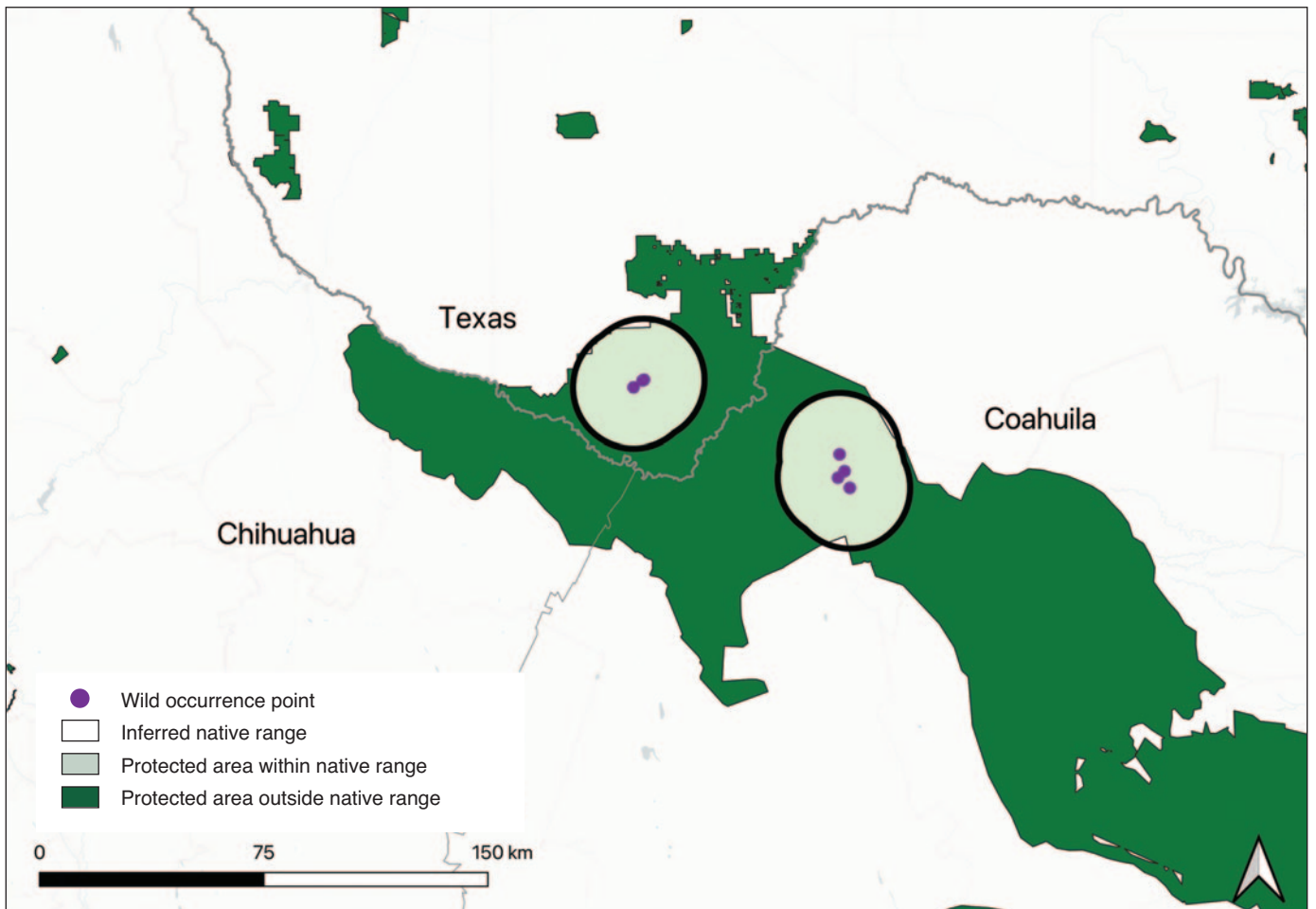


**Figure 4.** *Quercus carmenensis* wild occurrence points and ex situ collection source localities. Colored regions are Holdridge life zones. All ex situ collection source localities are also wild occurrence points.



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

**Table 3.** *In situ* conservation scores for *Quercus carmenensis* 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 <i>in situ</i>	98
Ecological coverage <i>in situ</i>	100
Species representation in <i>in situ</i> collections	100
Final <i>in situ</i> conservation score	99

**Land protection:** Within the species' inferred native range, 98% is covered by protected areas (Figure 5). The largest protected areas are Maderas del Carmen, Ocampo, and Cañón de Santa Elena. *Quercus carmenensis* is thought to be also found within ejidos like Los Lirios and San Francisco, a reserve purchased by CEMEX to promote conservation and restricted tourism, as well as private property. The species tends to be protected more within private property.

**Sustainable management of land:** *Quercus carmenensis* is found within the biosphere reserve Maderas del Carmen. All biosphere reserves in Mexico are required to have a management plan, which regulates activities in the area and ensures that objectives of the reserve are achieved. However, historically the implementation of the management plan within the region has been difficult because a majority of the land was either private ranges or ejidos where traditional land use practices were in place. In 2000, CEMEX launched the El Carmen Project with an aim to purchase land, negotiate conservation agreements, and develop and implement conservation plans (McKinney and Delgadillo Villalobos, 2004). Ultimately, CEMEX has purchased, or had a conservation agreement, for over 87,000 hectares.

**Population monitoring and/or occurrence surveys:** Few vegetation surveys have taken place in the Sierra del Carmen region since 1997, including a 2023 survey aimed at discovering new populations of *Q. carmenensis*. However, the observed *Quercus* individuals were identified belonging to different *Quercus* species other than *Q. carmenensis*, signifying the need for further botanical expedition.

**Wild collecting and/or ex situ curation:** This species is currently in four ex situ collections. Historically, there have also been collections of herbarium specimens. Currently the authors are working with managers of the protected zone to monitor phenology and potentially collect acorns in the 2024 season. Acorns were not collected during the most recent survey because trees were not accessible and individuals had not yet been positively identified.

**Propagation and/or breeding programs:** This is not a conservation activity at the time of publication.

**Reintroduction, reinforcement, and/or translocation:** This is not a conservation activity at the time of publication.

**Research:** This is not a conservation activity at the time of publication. Little is known regarding this species and more research is necessary. Populations should be located with precision and the ecology needs to be further studied.

**Education, outreach, and/or training:** There is education and outreach on the protected natural area and habitat, but nothing focusing on *Q. carmenensis* specifically.

**Species protection policies:** There are general protection policies for the habitat but not for *Q. carmenensis* specifically.

## PRIORITY CONSERVATION ACTIONS

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

### Population monitoring and/or occurrence surveys

Botanical surveys and field work are necessary to learn more about the basic ecology of this species (DBH, tree density, phenology, etc).

### Propagation and/or breeding programs

There is an urgent need to promote a propagation and reintroduction plan for this highly restricted species.



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