Conservation Gap Analysis of Native

# Mesoamerican Oaks


Béatrice Chassé

## Species profile: ***Quercus insignis***

Kate Good, Susana Valencia-A, Karina Orozco, Silvia Alvarez-Clare

### 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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# *Quercus insignis* Greene M.Martens & Galeotti

**Common Names, Spanish:** Chicalaba (MX), roble blanco (CR)
**IUCN Red List Category and Criteria: Endangered** B2ab(iii)

**Species profile experts:** Susana Valencia-A, Universidad Nacional Autónoma de México (UNAM); Karina Orozco, The Morton Arboretum; Silvia Alvarez-Clare, The Morton Arboretum

**Contributors:** Hernando Rodriguez Correa, UNAM Escuela Nacional de Estudios Superiores, Unidad Morelia

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## DISTRIBUTION AND BIOLOGY

*Quercus insignis* is a species with a wide distribution covering southern Mexico, Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rica, and western Panama (Figure 1). In Mexico it can be found on the Gulf and Pacific slopes with centers of distribution in the states of Jalisco and Veracruz (Rodriguez-Acosta et al., 2004). *Quercus insignis* is an emblematic species of the tropical montane cloud forest (subtropical moist forest and subtropical wet forest life zones) and grows at elevations between 750 and 2,500 m asl (Figure 2). This species is rare where it occurs, and forms low density populations in its fragmented habitat (González-Espinosa et al., 2011).


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

*Quercus insignis* is a large tree that can grow up to 50 m tall. The leaves are simple, alternate, wide and thinner at the base (obovate or obovate-elliptical). Leaves are smooth on the surface and densely hairy on the underside (yellowish-brown hairs below); they may appear reddish or bright green when young. This species produces some of the largest acorns of any species of oak, up to 10 cm in diameter. Acorns are variable in shape and have a dense layer of hairs before reaching maturity. (Morales, 2010)


Béatrice Chassé

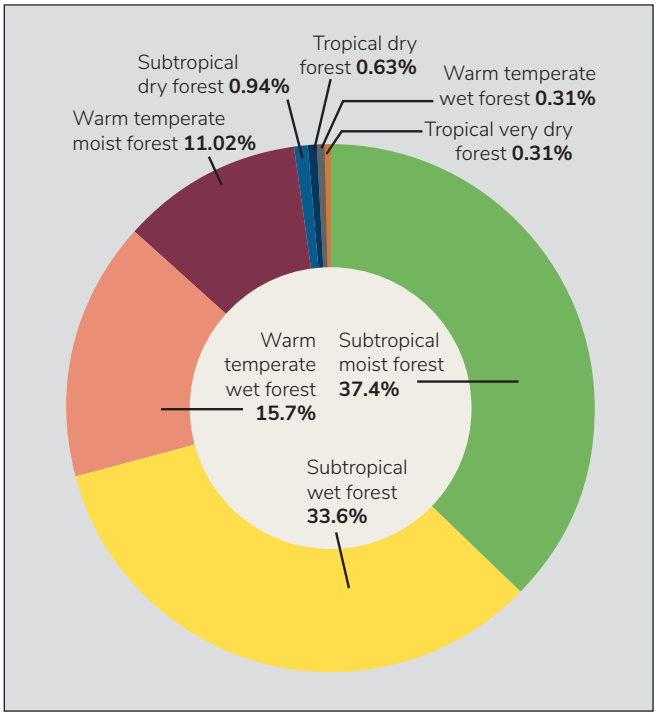


Figure 2. The percentage of wild occurrence points in each Holdridge life zone in which *Quercus insignis* is distributed.

## THREATS TO WILD POPULATIONS

**Human use of species — wild harvesting:** The fruit is used to make crafts and feed livestock. *Quercus insignis* wood is used in construction.

**Human use of landscape — agriculture, silviculture, ranching, and/or grazing:** Its native habitat is frequently deforested for coffee and ornamental plant cultivation, grazing, and urbanization.

**Human use of landscape — residential/commercial development, mining, and/or roads:** Although *Q. insignis* trees do not form dense stands, populations have been fragmented by the construction of roads, highways, and residential development.

**Human use of landscape — tourism and/or recreation:** In Mexico, one of the areas with the greatest presence of *Q. insignis* is the center of Veracruz, which has been altered by tourism.

**Human modification of natural systems — altered fire regime, pollution, eradication:** There is significant environmental contamination of rivers and areas surrounding the cloud forest where *Q. insignis* is distributed due to the proximity of human settlements.

**Human modification of natural systems — invasive species competition/disturbance:** The invasive fern species *Pteridium arachnoideum* has been documented in cloud forests within the native range of *Q. insignis*. A study by Toledo-Aceves et al. (2022) explored the use of two nurse shrubs to prevent the fern from outcompeting *Q. insignis* and another cloud forest tree species, which seemed to be effective in certain combinations.

**Climate change — habitat shifting, drought, temperature extremes, and/or flooding:** *Quercus insignis* is distributed in the cloud forest, one of the ecosystems that will be most impacted by climate change. Within the inferred native range of *Q. insignis*, the subtropical moist forest is expected to decrease in area by an average of 12% by the years 2061–2080 relative to current conditions (Good et al., 2024).

**Genetic material loss — inbreeding and/or introgression:** There are no known hybrids or introgression of *Q. insignis* in the wild and this is not currently considered a major threat. The scarcity of its individuals and the fragmented nature of its populations suggest inbreeding and consequently a decrease in genetic variability; however, ecological niche modeling of the species across its native range suggests high levels of genetic diversity within populations and high genetic connectivity between populations in Central America, especially in Costa Rica (Naranjo Bravo, 2021).

**Pests and/or pathogens:** Unknown.

**Extremely small and/or restricted population:** Although the species has a large range, populations are small, fragmented and naturally have a low density. The habitat is also very threatened; a significant amount of land within the species' native range has already been converted for agriculture and urbanization.

## 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. insignis* (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.

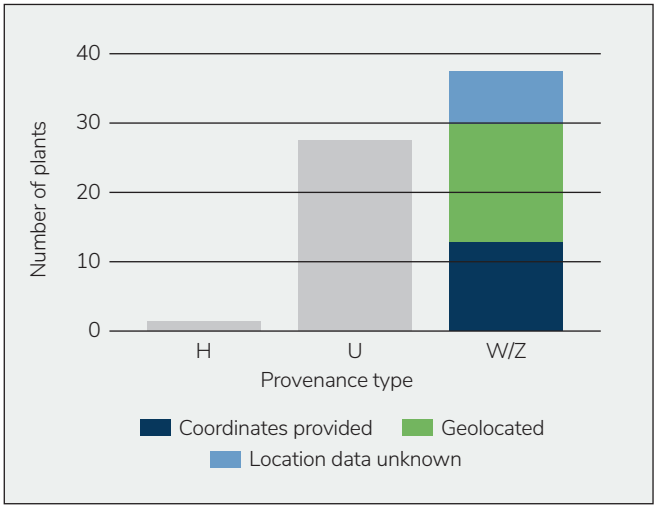


**Figure 3.** Number and origin of *Quercus insignis* plants in ex *situ* collections. Provenance types: H = horticultural; U = unknown; W = wild; Z = propagated from wild.

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

| | |
|---|---|
| Number of ex *situ* collections reporting this species | 24 |
| Number of plants in ex *situ* collections | 65 |
| Average number of plants per institution | 3 |
| Percent of ex *situ* plants of wild origin | 55% |
| Percent of wild origin plants with known locality | 83% |


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.

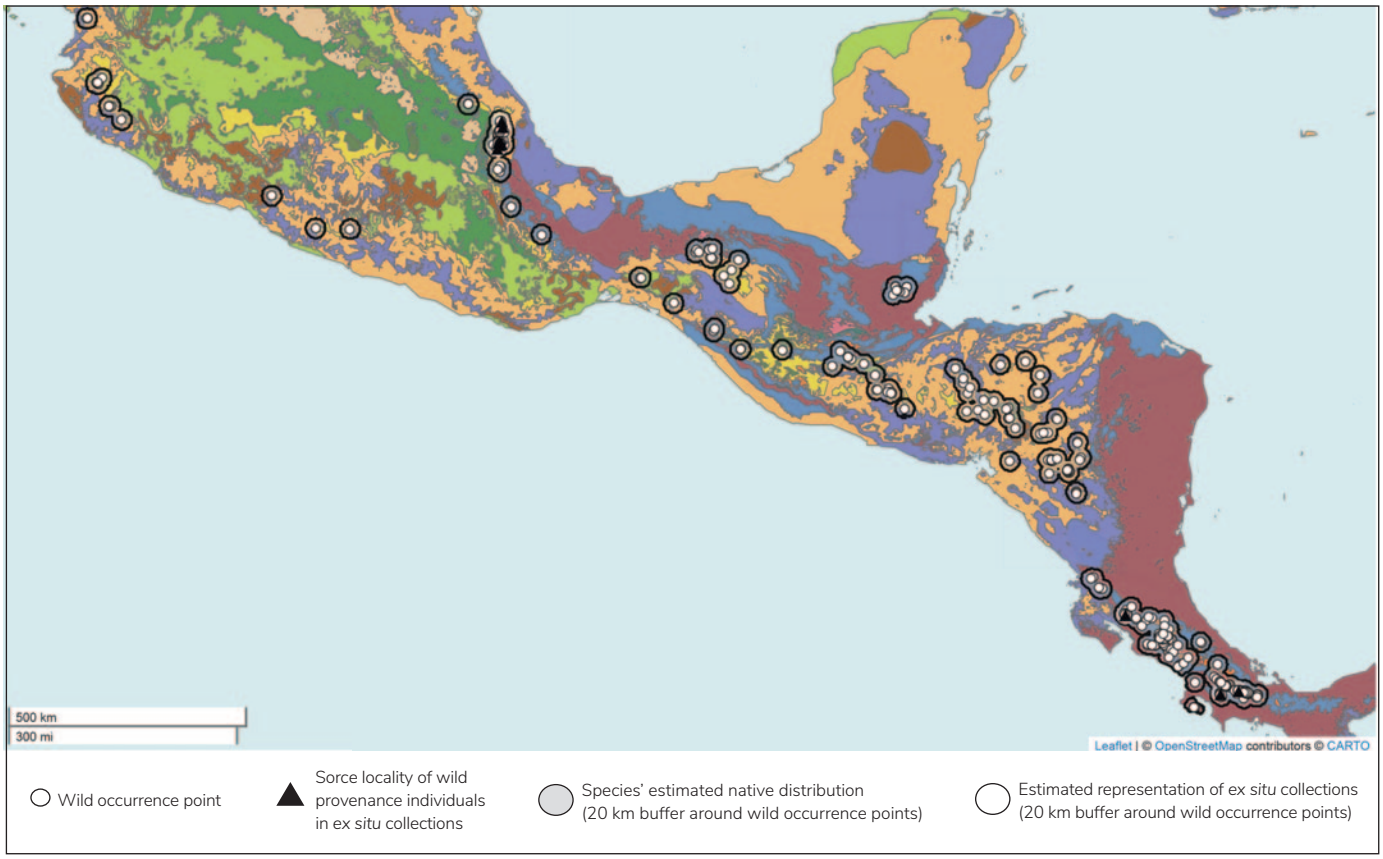


**Figure 4.** *Quercus insignis* wild occurrence points and *ex situ* collection source localities. Colored regions are Holdridge life zones. All *ex situ* collection source localities are also wild occurrence points.

Using methods adapted from Khoury et al. (2020), we estimated the degree of representation of *Q. insignis* 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 insignis* 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* | 7 |
| Ecological coverage *ex situ* | 76 |
| Representation in *ex situ* collections | 100 |
| Final *ex situ* conservation score | 61 |

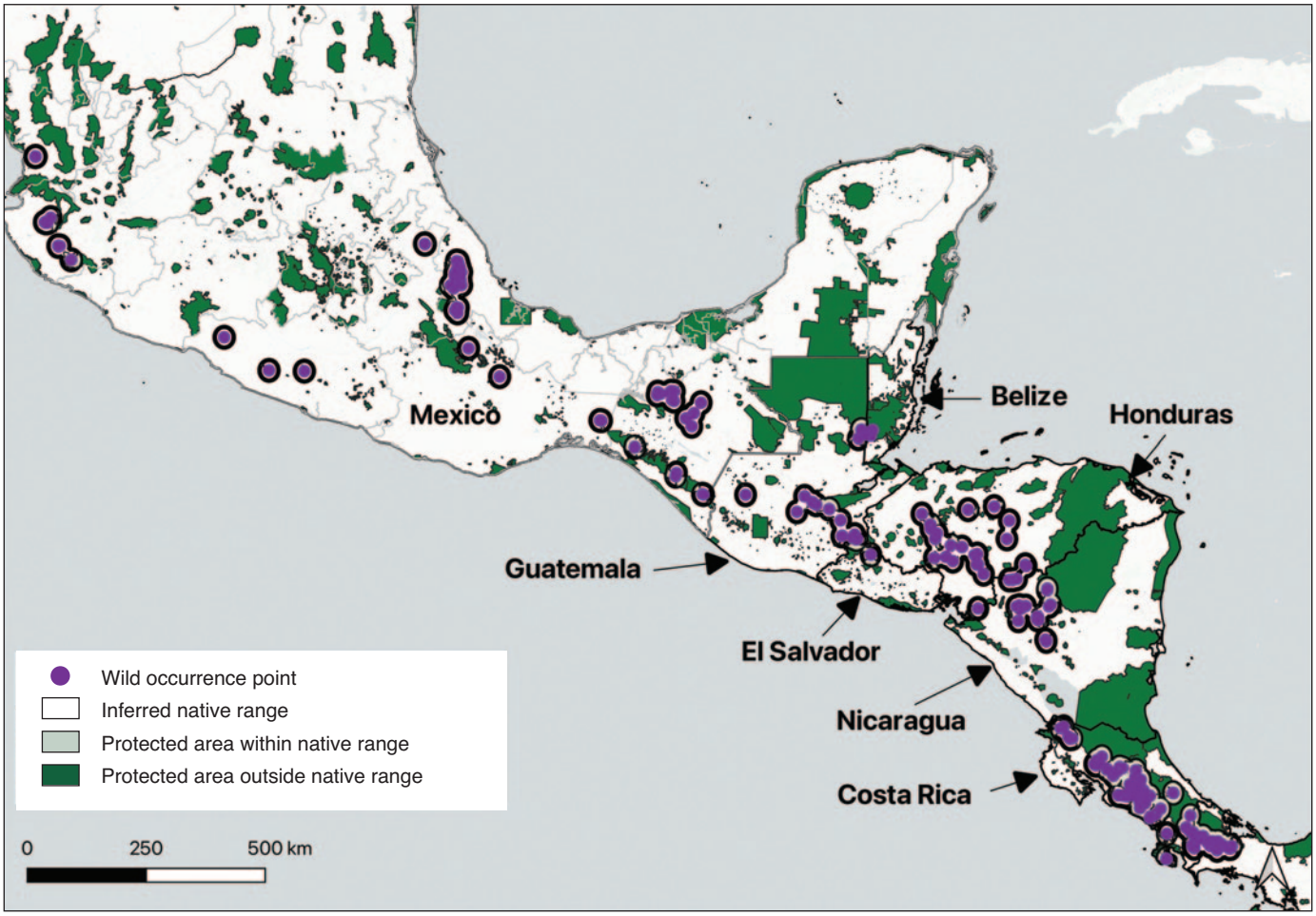


**Figure 5.** Wild occurrence points and inferred native range of *Quercus insignis* in relation to protected areas. Protected areas are from Protected Planet (UNEP-WCMC and IUCN, 2023.

**Table 3.** *In situ* conservation scores for *Quercus insignis* 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* | 30 |
| Ecological coverage *in situ* | 100 |
| Species representation in *in situ* collections | 52 |
| Final *in situ* conservation score | 61 |

**Land protection:** Within the inferred native range of *Q. insignis*, 30% is within protected areas (Figure 5). Most of the protected areas are in Costa Rica, and include the UNESCO-MAB Biosphere Reserve La Amistad and Arenal Monteverde, a National Protected Zone.

**Sustainable management of land:** There is a general management plan in place for La Amistad International Park in Costa Rica. There are patrols within the park to monitor and control illegal poaching and logging, and threats are monitored using a Spatial Monitoring and Reporting Tool (SMART). There is also a draft management plan in place for the Panamanian side of the park. The extent of sustainable land management in this species' range outside of Panama and Costa Rica is unknown. (UNESCO, 2023)

**Population monitoring and/or occurrence surveys:** Populations of *Q. insignis* in Mexico and Costa Rica are being monitored to track phenology as part of a montane cloud forest conservation project through the Global Conservation Consortium for Oak (GCCO). Part of this project resulted in the creation of an updated occurrence map for the species in Costa Rica [unpublished], which was reviewed and verified by taxonomic experts in the country.

**Wild collecting and/or *ex situ* curation:** According to the results of our *ex situ* surveys, this species is in 24 *ex situ* collections.

**Propagation and/or breeding programs:** There are records that some nurseries in the center of Veracruz, Mexico have propagated *Q. insignis* seedlings to reforest the cloud forest. This is also the case for nurseries in the northern, central and southern regions of Costa Rica via conservation work with NGOs and the National System of Conservation Areas (SINAC). Chevithorne Barton in Devon, UK has successfully rooted cuttings of *Q. insignis*.

**Reintroduction, reinforcement, and/or translocation:** The Costa Rica based NGO Osa Conservation has been working to reforest and maintain connectivity within the Amistosa Biological Corridor by transplanting thousands of native tree seedlings, including *Q. insignis*, into pastures and farms within the cloud forest. Seedlings have a high rate of survival both in the nursery and after transplant to the field, and plants that have been reintroduced grow better when the substrate is enriched with organic soil and earthworms (Orozco et al., in prep).

**Research:** The biogeography of *Q. insignis* was first studied by Rodríguez-Correa et al. (2017) through genetic analysis and ecological niche modeling. According to the study, the main mountain ranges of Costa Rica have supported a climate suitable for *Q. insignis* since the Last Glacial Maximum (LGM) about 21,000 years ago.

The ecology of *Q. insignis* and other cloud forest species has been studied (Toledo Aceves and del-Val, 2020; Toledo-Aceves et al., 2022) as well as the ecology of its seed dispersal (García-Hernández et al., 2023). Research on seedling survival and relative growth has been done over four years with conditions such as 1.4° C increase, and a 25–30% annual precipitation decrease (Toledo-Aceves et al., 2023). In general, *Q. insignis* is very tolerant to various conditions whether as a seed or seedling. In simulated predation tests, large seeds could tolerate and grow successfully with damage of less than one-third of the cotyledon. Germination tests have also shown that healthy seeds have high germination rates in both sun and shade, and are equally successful in seedbeds or nursery bags (Orozco et al., in prep).

A study conducted by Montes-Hernández and López-Barrera (2013) found that *Q. insignis* seedlings had higher rates of survival and stem growth under mulch and shade. Additionally, there was more root predation for seedlings growing without cover. A similar study found more desiccation and predation on seedlings not growing under fast-growing facilitating trees for three cloud forest species, including *Q. insignis* (Avendaño-Yáñez et al., 2014). More research is needed to determine the best condition and practices for its restoration across the entirety of its range.

**Education, outreach, and/or training:** As part of a conservation research project funded by National Geographic Society, several professionals in the field of restoration, resource management, and conservation were trained in rare and threatened species identification in southern Costa Rica. This training took place at a workshop in November 2022 at the ASADA- Gutierrez Brawn in San Vito de Coto Brus, directly adjacent to native cloud forest patches where participants collected samples of the species. Species ID guides for *Q. insignis* and other cloud forest trees were also shared during the training. Additionally, a propagation protocol was created and published based on research conducted during the same project (Orozco et al. 2023).

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

## PRIORITY CONSERVATION ACTIONS

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

### Land protection

The establishment of new protected areas is necessary to avoid additional losses of trees, especially in Mexico, Guatemala, Nicaragua, and Honduras.

### Education, outreach, and/or training

Education that allows local communities to be involved in the care of the species should be a priority.

### Reintroduction, reinforcement, and/or translocation

Assisted migration of seedlings to sites with future environmental conditions suitable for the development of the species is necessary to conserve *Q. insignis* into the future.

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