Conservation Gap Analysis of Native

# Mesoamerican Oaks


## Species profile: ***Quercus brandegeei***

Daniel W. Pérez Morales, Kate Good, 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 brandegeei* Goldman

**Common Names, Spanish:** Encino Arroyero
**IUCN Red List Category and Criteria: Endangered:** B1ab(iii,v)c(iv)+2ab(iii,v)c(iv)

**Species profile expert:** Daniel W. Pérez Morales, The University of Chicago and the Morton Arboretum

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## DISTRIBUTION AND BIOLOGY

*Quercus brandegeei* is endemic to the Cape Region, located at the southern tip of the Baja California peninsula, Mexico (Figure 1). One of the characteristic features of the physiography of the Cape Region is the Sierra de la Laguna, a mountain massif that runs from north to south with a maximum altitude of 2,100 meters above sea level. Along the altitudinal gradient different types of vegetation develop. At lower elevations sarcocaule scrub is located. From 300 to 1,000 m is the only deciduous lowland forest or dry tropical forest on the peninsula, and above 1,000 m are the holm oak forests and the pine-oak forest. In addition, there is riparian vegetation from approximately 800 meters in altitude (Breceda, 1994; CONANP, 2003). This plant community is characterized by the "güeribo" (*Populus brandegeei* var. *glabra*) and palm trees such as the black palm or palmilla (*Erythea brandegeei*) and the royal palm or leaf palm (*Washingtonia robusta*). It is in this type of vegetation where the individuals of *Q. brandegeei* are distributed. Populations of *Q. brandegeei* are sparsely distributed in patches on the banks of streams at altitudes no higher than 800 m. A majority of known occurrences are within the subtropical thorn woodland life zone (Figure 2).

*Quercus brandegeei* is a medium-sized evergreen oak that averages heights of 10–12 meters, and up to 20 m (Denvir and Westwood, 2016). It has gray furrowed bark and a wide, extended crown that can measure an average of 20 m2. In this species, a mainly annual fruit ripening cycle has been observed, completing ripening in autumn and winter. It is a species that alternates between abundant and scarce, or even no acorn production. It presents great polymorphism in shape, coloration and dimensions of both the leaves and its fruits. The acorns measure 3–4.5 cm long, 1–1.2 cm wide, are fusiform, and have an attenuated, glabrous and opaque brown beak at the apex (Muller, 1961; Cavender-Bares et al., 2015; Pérez-Morales, 2021).

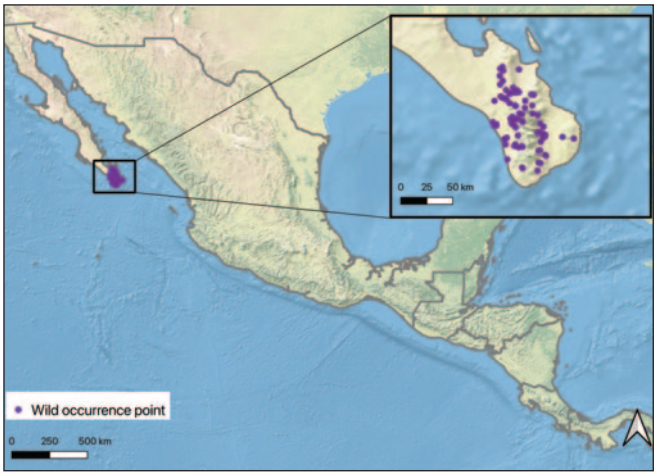


**Figure 1.** Wild (i.e., *in situ*) occurrence points for *Quercus brandegeei*.

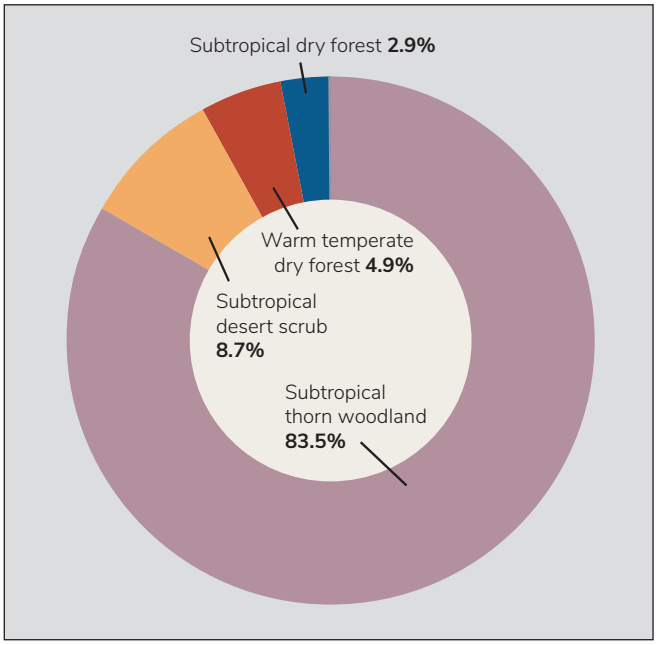


**Figure 2.** The percentage of wild occurrence points in each Holdridge life zone in which *Quercus brandegeei* is distributed.

## THREATS TO WILD POPULATIONS

**Human use of species — wild harvesting:** Acorns of *Q. brandegeei* are used to feed livestock and are also ground into flour and to make atole (Brinckwirth et al., 2023). The wood is used for charcoal, fuel, and fence posts (Pérez-Morales, 2021).

**Human use of landscape — agriculture, silviculture, ranching, and/or grazing:** Within the Sierra la Laguna Biosphere Reserve, there are just under a hundred ranches with mainly cattle. There are also ranches on the banks of streams that have small orchards where fruit and vegetables are grown, in addition to livestock (Castorena and Breceda, 2008). The effects of livestock farming on the vegetation of the low deciduous forest has resulted in the loss of diversity of herbaceous species (Breceda et al., 1997; 2012).

**Human use of landscape — residential/commercial development, mining, and/or roads:** There is mining and quarrying within *Q. brandegeei* habitat. Sand is extracted from arroyos and used for construction.

**Human use of landscape — tourism and/or recreation:** Ecotourism is an increasingly popular activity within the Sierra La Laguna Biosphere Reserve, with approximately 1,340 tourists from Mexico and 540 foreign tourists every year (UNESCO, 2018). There is a lack of environmental education and regulation of recreational activities.

**Human modification of natural systems — altered fire regime, pollution, eradication:** Forest fires are a major threat to the Sierra la Laguna Biosphere reserve. Large fires that can last months occur at least once a century (León-de la Luz and Domínguez-Cadena, 2010). Ground level fires are most common, but more destructive crown level fires are possible due to accumulation of deadwood and debris. Most old trees in the oak-pine forest within the reserve display fire scars.

**Human modification of natural systems — invasive species competition/disturbance:** The rubber vine (*Cryptostegia grandiflora*) is an invasive parasitic species that affects the oaks. First recorded in Baja California Sur in 1935, this species has caused great ecological impact to the area (Rodríguez-Estrella et al., 2010). It is an aggressive weed with high spreading potential and has been observed covering individuals of *Q. brandegeei*.

**Climate change — habitat shifting, drought, temperature extremes, and/or flooding:** On the Baja California peninsula, an increase in aridity is estimated with a reduction in winter-spring precipitation in the north and summer precipitation in the center and south (Cavazos and Arriaga-Ramírez, 2012). In the short term, these climate projections can cause a decrease in acorn production and in the longer term, this can increase the interval between acorn years (Brinckwirth et al., 2023). Regardless of the exact mechanism that is preventing the species' natural regeneration, habitat loss caused by drying out ephemeral stream beds remains a major threat to the species. Researchers who have worked with this species propose that this drying could be caused by long-term climate change (Cavender-Bares et al., 2015; Alvarez-Clare and León de la Luz, personal communication, 2023). Other studies that model climate change predictions for Mexico corroborate this theory by predicting a reduction in precipitation in southern Baja California caused by global warming temperatures (Cavazos and Arriaga-Ramírez, 2012). More research is needed into the effects that drought and climate change will have on this type of habitat.


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**Genetic material loss — inbreeding and/or introgression:** *Quercus brandegeei* has lower genetic diversity than other related species of oaks (Cavender-Bares et al., 2015).

**Pests and/or pathogens:** This is not currently considered a threat at the time of publication.

**Extremely small and/or restricted population:** *Quercus brandegeei* is restricted to the southern tip of the Baja California peninsula, Mexico.

## 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. brandegeei* (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.

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

| | |
|---|---|
| Number of *ex situ* collections reporting this species | 10 |
| Number of plants in *ex situ* collections | 49 |
| Average number of plants per institution | 5 |
| Percent of *ex situ* plants of wild origin | 65% |
| Percent of wild origin plants with known locality | 41% |

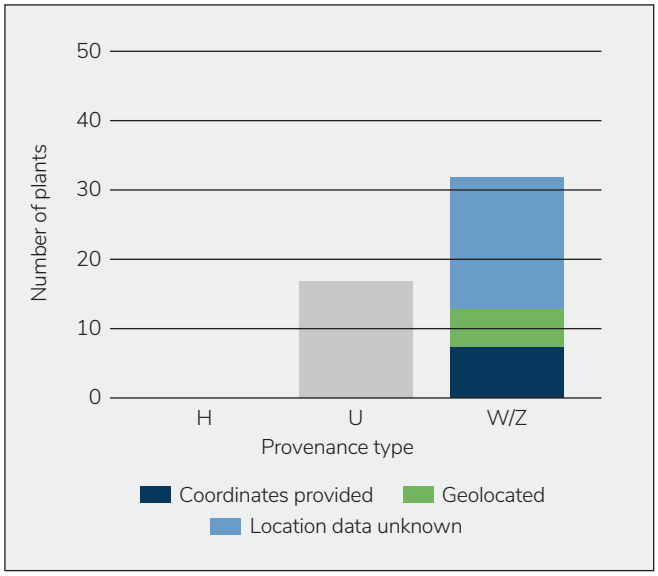


**Figure 3.** Number and origin of *Quercus brandegeei* plants in *ex situ* collections. Provenance types: H = horticultural; U = unknown; W = wild; Z = propagated from wild.

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.

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

**Table 2.** *Ex situ* conservation scores for *Quercus brandegeei* 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* | 63 |
| Ecological coverage *ex situ* | 100 |
| Representation in *ex situ* collections | 60 |
| Final *ex situ* conservation score | 74 |

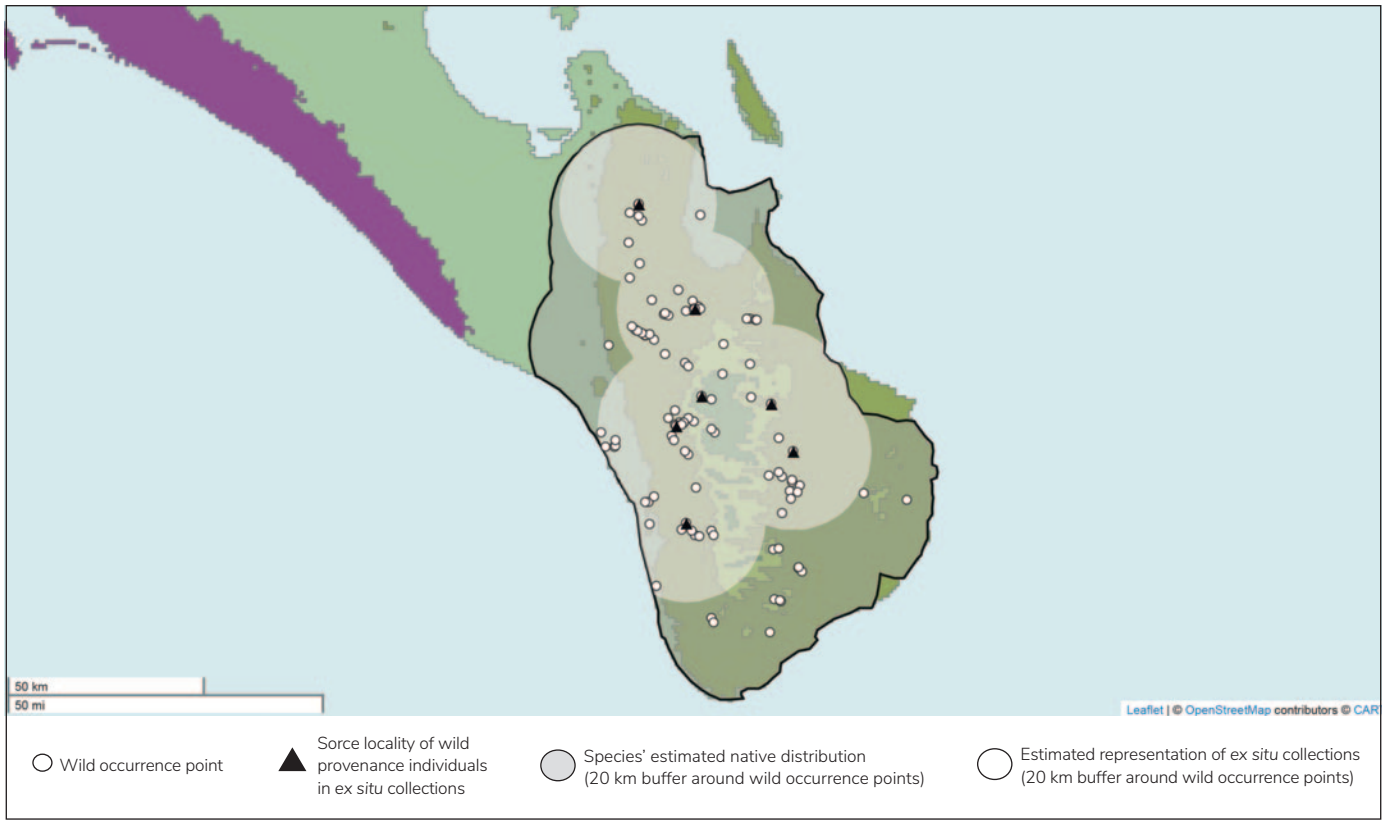


**Figure 4.** *Quercus brandegeei* wild occurrence points and ex *situ* collection source localities. Colored regions are Holdridge life zones. All ex *situ* collection source localities are also wild occurrence points.

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.

**Land protection:** Within the inferred native range of *Q. brandegeei*, 26% is within protected areas (Figure 5). The two protected areas within the species' native range in Baja California Sur are Sierra La Laguna Biosphere Reserve and the Sistema Ripario de la Cuenca y Estero de San José del Cabo.

**Sustainable management of land:** Much of the population of *Q. brandegeei* occurs within the Sierra La Laguna Biosphere Reserve. 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.

**Population monitoring and/or occurrence surveys:** Since 2018, visits have been made to six different populations of *Q. brandegeei* within its distribution range, during which population, location and production data are recorded. In 2023 a census was performed in three populations (San Dionisio, La Cobriza and Las Matancitas) to estimate the number of individuals in each population and to determine their genetic diversity.

**Wild collecting and/or ex *situ* curation:** According to the results of our ex *situ* surveys, this species is currently held in 10 ex *situ* collections. Outreach is currently being made to botanic gardens within the region to identify new potential ex *situ* institutions who may add *Q. brandegeei* to their collections.

**Propagation and/or breeding programs:** Over 5,500 juveniles have been propagated in local nurseries.

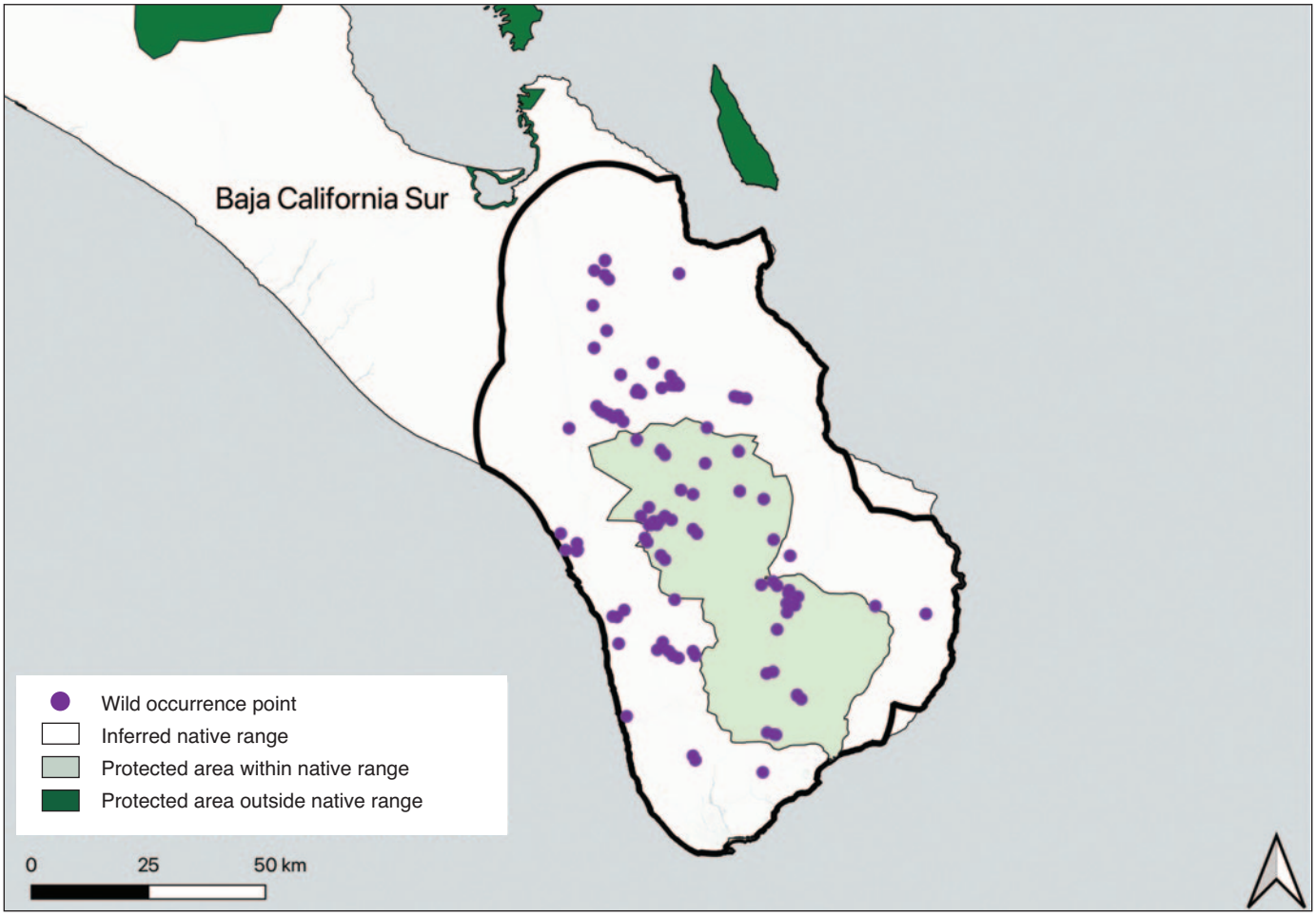


Figure 5. Wild occurrence points and inferred native range of *Quercus brandegeei* in relation to protected areas. Protected areas are from Protected Planet (UNEP-WCMC and IUCN, 2023.

Table 3. *In situ* conservation scores for *Quercus brandegeei* 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* | 26 |
| Ecological coverage *in situ* | 100 |
| Species representation in *in situ* collections | 45 |
| Final *in situ* conservation score | 57 |

**Reintroduction, reinforcement, and/or translocation:** A solid network of protectors of the species under the "Salvemos al Encino Arroyero" program has formed. More than 1,500 oak trees have been adopted in 26 ranches in 12 locations. In addition, seedlings are propagated in local nurseries and enrichment plantations are carried out in strategic places within the range of the species, ensuring that a new cohort of trees grows safely.

**Research:** In 2018, viability estimates of *Q. brandegeei* populations were made from analysis of the seed. Laboratory and greenhouse studies were performed where the viability of acorns and their morphology was evaluated (Pérez-Morales, 2021).

In 2019, an experiment was established in which the mortality of 700 *Q. brandegeei* seedlings was monitored on the banks of a stream in the community of San Dionisio, within the Sierra La Laguna Biosphere Reserve. Seedlings were transplanted inside and outside of exclusions and in the presence and absence of canopy. At each site, a camera trap was installed to quantify the intensity and frequency of mammal activity. As expected, evidence of grazing was significantly lower within the exclusions, confirming that the removed seedling parts and tissues were caused by grazing and trampling by domestic animals.

Camera traps installed at each site captured a total of 27 different cows (*Bos taurus*), 27 goats (*Ovis aries*) and 26 pigs (*Sus scrofa domestica*), which were recorded regularly grazing or trampling seedlings. After a year, almost all the transplanted seedlings (624 of the 700 seedlings initially planted) were dead or gone, revealing the extremely harsh conditions that *Q. brandegeei* seedlings face, at least when grown near ranches. A 2023 study by Brinckwirth et al. investigated spatial aggregation in *Q. brandegeei*, and found that this is a highly clumped species, with the most pronounced aggregation at 0–25 m.

A current research project by a PhD candidate at the University of Chicago aims to perform a more intensive cataloging and genetic sampling of selected *in situ* populations as well as *ex situ* individuals which have been planted as a part of restoration efforts. The objective is to explain the historical, contemporary, and potential future evolutionary dynamics (e.g., changes in population size, gene flow, and bioclimatic niche occupancy) of *Q. brandegeei* in an effort to better evaluate the effectiveness of past conservation efforts as well as gauge how to improve future conservation efforts.

**Education, outreach, and/or training:** Knowledge on the importance and conservation status of *Q. brandegeei* has been shared with more than 50 people, including members of communities and social groups, park rangers and decision makers with sufficient knowledge about the species, guaranteeing its proper management and conservation.

Young people within the area have been informed about the importance of conserving *Q. brandegeei* through community workshops, as well as the documentary film "Salvemos al Encino Arroyero" and an annual festival "Festival Comunitario de Conservación del Encino Arroyero".

**Species protection policies:** There is no legal framework for protecting *Q. brandegeei* in Mexico. However, an Action, Management and Conservation Plan for *Q. brandegeei* has been developed through a participatory process with local stakeholders (Morton Arboretum, 2023). This plan identifies the most urgent threats facing *Q. brandegeei*, as well as specific actions needed to address each threat with the ultimate goal of rescuing and regenerating the species.

## PRIORITY CONSERVATION ACTIONS

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

### Research

There is a need for more genetic studies of the populations present in the region. This information could be used to create corridors that allow for connection and gene flow between populations, prioritizing areas where there is less genetic variability. There is also a need for floristic and structural composition studies in the region where the species occurs in order to establish the conservation status of the area. Finally, more research on the effects of climate change on *Q. brandegeei* should be a priority.

### Education, outreach, and/or training

Education and outreach is needed to allow for the exchange of knowledge, values and experiences between those who study *Q. brandegeei* and the community. There is also a need to promote the sustainable management of *Q. brandegeei* to improve the habitat quality without negatively impacting the basic needs of the community.

### Reintroduction, reinforcement, and/or translocation

*In situ* conservation is necessary to improve populations with structural, health and habitat problems. It can also be a strategy to support healthy populations, preserving their dynamics and prolonging their permanence over time.

### Population monitoring and/or occurrence surveys

There is a need to establish monitoring protocols. This would allow for quantifying the success of conservation activities as well as identifying the current state of groves or patches where the species is established.

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