

# Conservation Gap Analysis of Native Mesoamerican Oaks



Francisco Garin

## Species profile: *Quercus macdougalii*

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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 macdougalii***  
*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 macdougallii* Martínez

**Common Names:** Yaa dua yu (Zapotec), 'Ma kue (Chinantec)

**IUCN Red List Status:** Endangered B1ab(iii)+2ab(iii)

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## DISTRIBUTION AND BIOLOGY

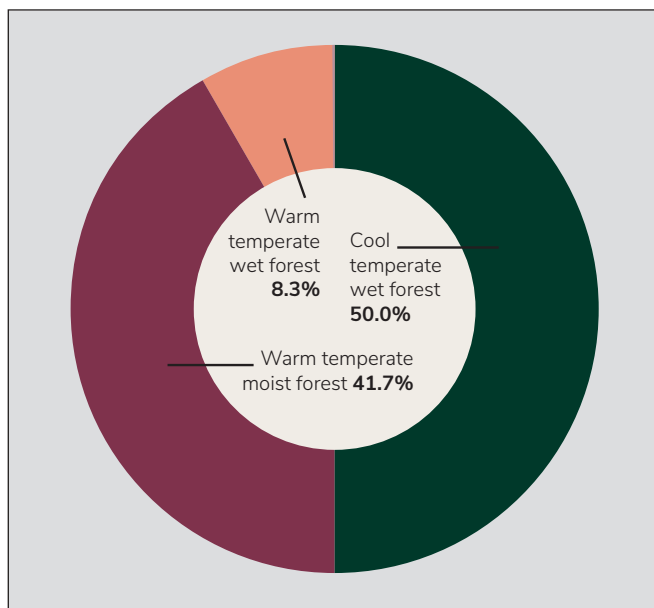
*Quercus macdougallii* a microendemic species in La Sierra Juárez, Oaxaca, Mexico (Figure 1). It is distributed on the slopes of Cerro Zacate (San Pedro Yólox) and Humo Grande (Santiago Comaltepec) at elevations 2,400 to 3,040 m asl (González-Espinosa et al., 2011; Clark-Tapia et al., 2018). Recently, more individuals have been discovered in Ixtlán de

Juárez on the Shia Rua Via mountain (also known as “Los Pozuelos”; Pacheco-Cruz, 2019). At its lower elevation range (< 2,600 m) there is low abundance of primarily young individuals 6 m and less in height. At higher elevations (2,750–2,950 m) there is greater abundance with all age classes found, including large mature trees (Clark-Tapia et al., 2018). Where it grows, *Q. macdougallii* can dominate the forest (Pacheco-Cruz, 2022). It is found primarily in two Holdridge life zones: cool temperate wet forest and warm temperate moist forest (Figure 2).

*Quercus macdougallii* varies greatly in size and habit. It can grow up to 40 m tall while displaying an arboreal habit, or grow as a relatively small shrub (González-Espinosa et al., 2011). The leaves are also variable in shape, with young leaves typically being oblong-elliptic, leathery, and shiny (Pacheco-Cruz, 2022).



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



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

## THREATS TO WILD POPULATIONS

**Human use of species — wild harvesting:** Unknown.

**Human use of landscape — agriculture, silviculture, ranching, and/or grazing:** Areas where *Q. macdougalii* grow have historically been used for agriculture, livestock and forestry.

**Human use of landscape — residential/commercial development, mining, and/or roads:** Some populations of *Q. macdougalii* have been fragmented by the construction of roads and highways.

**Human use of landscape — tourism and/or recreation:** In Ixtlán de Juárez, ecotourism activities are carried out in the Shia Rua Via mountain to visit the cloud forest and the “sacred tree” which is an individual of *Q. macdougalii*. In the highest part of Cerro Zacate, surrounded by specimens of *Q. macdougalii*, the people of San Pedro Yólox built a Catholic church.

**Human modification of natural systems — altered fire regime, pollution, and/or eradication:** It has been reported that the distribution area of *Q. macdougalii* has suffered from fires as well as snowfall. There is also forest thinning and elimination of *Q. macdougalii* trees in favor of the establishment of species with economic importance such as *Pinus patula*.

**Human modification of natural systems — invasive species competition/disturbance:** Unknown. Proliferation of genus *Cuscuta* near *Q. macdougalii* habitat has been observed harming pines within the area, but it is not yet known if it affects oaks.

**Climate change — habitat shifting, drought, temperature extremes, and/or flooding:** The species is distributed at high elevations and is susceptible to climate change, due to a reduction in sites with adequate temperature and humidity conditions for its development. Within the inferred native range of *Q. macdougalii*, the cool temperate wet forest is expected to decrease in area by an average of 100% by the years 2061–2080 relative to current conditions (Good et al., 2024).

**Genetic material loss — inbreeding and/or introgression:** The genetic and allelic diversity found in previous studies is considered relatively low compared to other oak species (Molina, 2011). Massive sequencing of 79 individuals identified 8,186 single nucleotide polymorphisms (SNPs) and confirmed a low genetic diversity. It was reported that the species behaves as a single population with a gradient of genetic variation towards the south of its distribution, suggesting a possible incipient genetic group (Pacheco-Cruz, 2019).

**Pests and/or pathogens:** Some infestation of acorns by insect larvae and *Curculionidae* has been reported, which reduces the viability of the acorns.

**Extremely small and/or restricted population:** *Quercus macdougalii* is a microendemic species from the Sierra Norte of Oaxaca. In the Cerro Zacate-Humo Grande area, *Q. macdougalii* is only found at elevations above 2,600 m, mainly around 2,900 m, and some populations only have 150 trees per hectare. Young individuals and seedlings are rarely observed in Sierra Juárez, Oaxaca (Nelly Pacheco-Cruz, personal communication, 2024).

## CONSERVATION ACTIVITIES

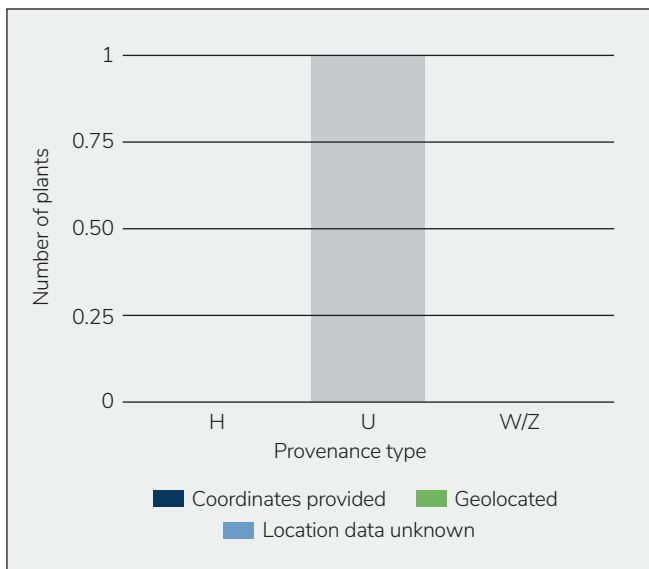
Once per year between 2017 and 2022, *Quercus* accessions data were requested from ex situ collections globally. A total of 197 institutions from 27 countries submitted data for Mesoamerican oak species, including *Q. macdougalii* (Table 1, Figure 3). Past, present, and planned conservation activities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

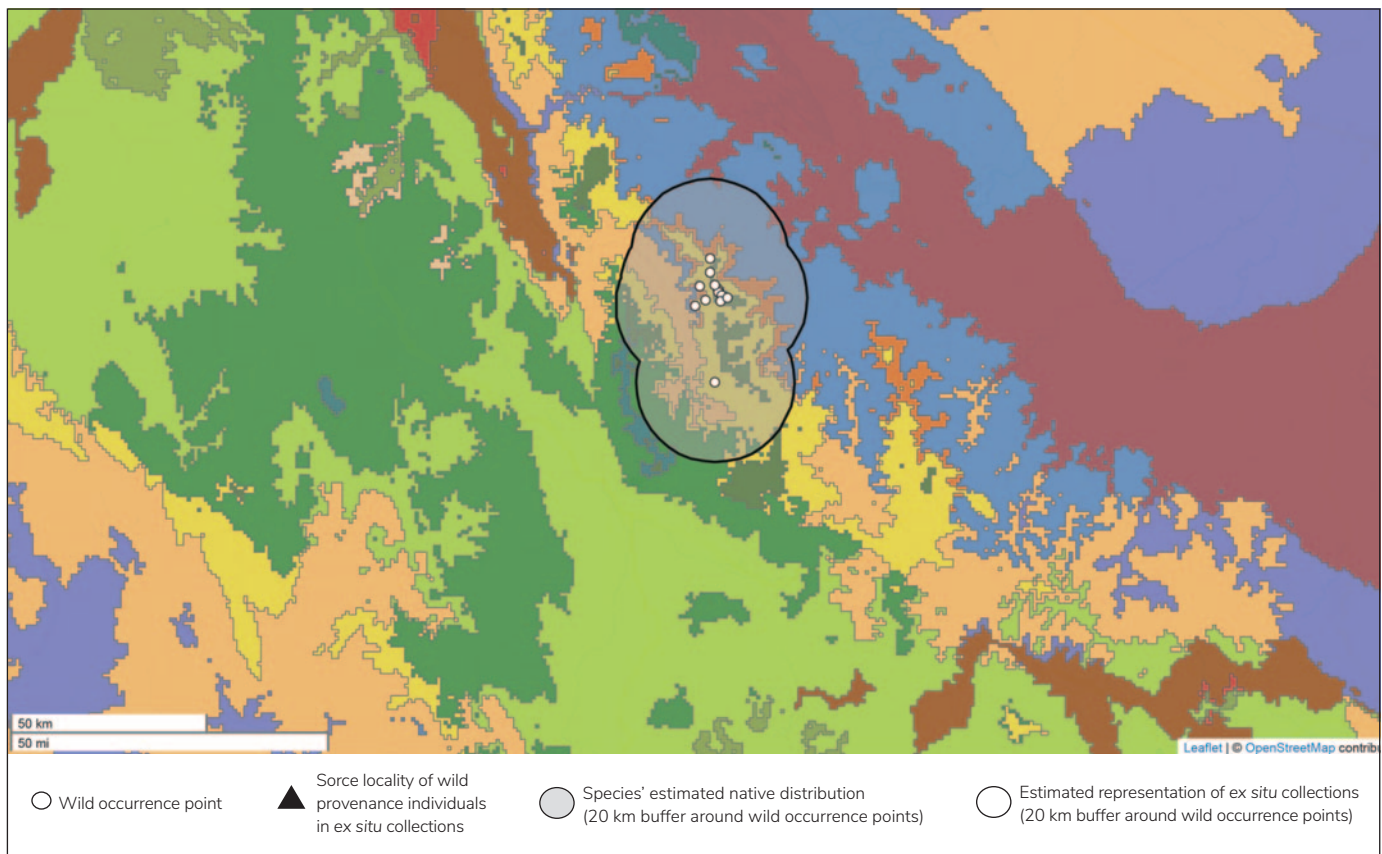
**Table 1.** Results of 2017–2022 ex situ surveys.

Number of ex situ collections reporting this species	1
Number of plants in ex situ collections	1
Average number of plants per institution	1
Percent of ex situ plants of wild origin	0%
Percent of wild origin plants with known locality	0%



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





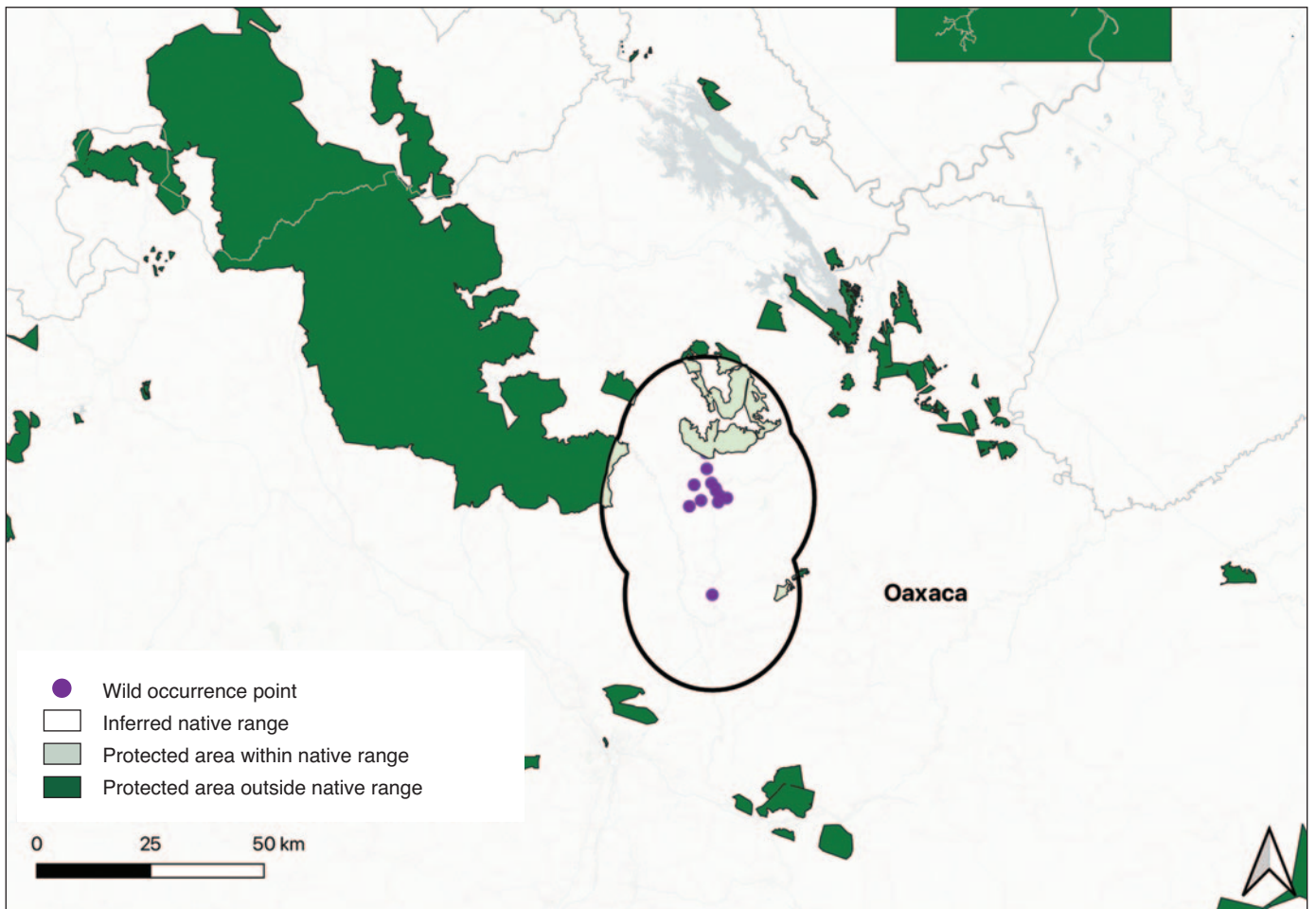
**Figure 4.** *Quercus macdougalii* wild occurrence points and ex situ collection source localities. Colored regions are Holdridge life zones. All ex situ collection source localities are also wild occurrence points.

**Table 2.** Ex situ conservation scores for *Quercus macdougalii* 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	0
Ecological coverage ex situ	0
Representation in ex situ collections	0
Final ex situ conservation score	0

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



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

**Table 3.** *In situ* conservation scores for *Quercus macdougallii* 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>	9
Ecological coverage <i>in situ</i>	78
Species representation in <i>in situ</i> collections	9
Final <i>in situ</i> conservation score	32

**Land protection:** Within the species' inferred native range, 9% is covered by protected areas (Figure 5). Nearby protected areas are primarily Voluntary Conservation Areas, and include Área de Conservación Nopalera del Rosario and La Tierra del Faisán.

**Sustainable management of land:** Unknown.

**Population monitoring and/or occurrence surveys:**

Anacleto-Carmona (2015) studied, as a bachelor thesis, the abundance of trees of different ages of *Q. macdougallii* in its distribution area. In a 2018 study on *Q. macdougallii* reproduction carried out by Clark-Tapia et al., the distribution area was surveyed for sampling and collecting acorns. In addition, *Q. macdougallii* recently received a grant from the IOS Oak Conservation and Research (OC&R) Fund (Byrne, 2023). This project will focus on surveying *Q. macdougallii* to better understand distribution and population structure, as well as identify the variables that impact its abundance.

**Wild collecting and/or ex situ curation:**

According to the results of our *ex situ* surveys, this species is currently in one *ex situ* collection of unknown provenance.

**Propagation and/or breeding programs:** Unknown.



**Reintroduction, reinforcement, and/or translocation:** The study by Clark-Tapia et al. (2018) reintroduced seedlings at different elevations from which the species is distributed, finding that the highest percentage of survival occurred at 2850 m.

**Research:** There has been research for *Q. macdougallii* focusing on reproduction (Clark-Tapia, et al., 2018), genetic diversity (Molina, 2011) and wood anatomy (Ruiz-Aquino et al., 2020). The possible genes associated with local adaptation are currently being investigated through bioinformatics analysis using sequencing data from 79 individuals. In addition, a descriptive analysis of the soil where the species is found is currently being carried out (Pacheco-Cruz, in prep).

**Education, outreach, and/or training:** Education and outreach is part of the 2023 IOS Oak Conservation and Research (OC&R) fund by raising awareness of this threatened species in the local community.

**Species protection policies:** *Quercus macdougallii* is the only endemic Mexican oak that is listed as threatened in the Mexican Federal List of Endangered Species (NOM-59). As a result, it is very difficult to collect *Q. macdougallii* and special permits are required to work with this species.

## PRIORITY CONSERVATION ACTIONS

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

### Land protection

There are very few protected areas within the inferred native range of *Q. macdougallii*. Establishment of protected areas is necessary to avoid additional losses of trees of this species.

### Education, outreach, and/or training

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

### Propagation and/or breeding programs

Wild collecting as well as establishing a propagation program are necessary to support this highly restricted species.

### Reintroduction, reinforcement, and/or translocation

The habitat and altitude where this species develops will be among the most affected by climate change. As a result, assisted migration of seedlings to sites with future environmental conditions suitable for the development of the species is needed.

## REFERENCES

Anacleto-Carmona, E. 2015. Abundancia y distribución de *Quercus macdougalii* (Fagaceae), especie endémica de la Sierra Juárez. Tesis de Licenciatura. Universidad de la Sierra Juárez, Ixtlán de Juárez, Oaxaca, México.

Byrne, A. 2023. "OC&R Committee Announces Second Round of Grant Funding". International Oak Society. Available at <https://www.internationaloaksociety.org/content/ocr-committee-announces-second-round-grant-funding>. Accessed April 2024.

Clark-Tapia, R., Mendoza Ochoa, A., Aguirre-Hidalgo, V., Antúnez, P., Campos Contreras, J. E., Luna-Krauletz, M. D., and Alfonso-Corrado, C. 2018. Reproducción sexual de *Quercus macdougalii*, un encino endémico de la Sierra Juárez, Oaxaca. *Madera y bosques* 24(2). <https://doi.org/10.21829/myb.2018.2421617>

González-Espinosa, M., Meave, J. A., Lorea-Hernández, F. G., Ibarra-Manríquez, G. and Newton, A.C. (eds). 2011. The Red List of Mexican Cloud Forest Trees. pp. 152. FFI, BGCI, Cambridge, UK.

Good, K., Coombes, A. J., Valencia-A, S., Rodríguez-Acosta, M., Beckman Bruns, E., and Alvarez-Clare, S. 2024. Conservation Gap Analysis of Native Mesoamerican Oaks. Lisle, IL: The Morton Arboretum.

Khoury, C. K, Carver, D., Greene, S. L., and Frances, A. 2020. Crop wild relatives of the United States require urgent conservation action. *PNAS* 117(52): 33351–33357.

Molina, G. C. 2011. Diversidad genética y estructura poblacional de *Quercus macdougalii*, encino endémico de Oaxaca, México. Tesis Licenciatura, Facultad de Estudios Superiores Iztacala, UNAM. 71 pag.

Pacheco-Cruz, N. 2019. Variación genómica y distribución potencial de *Quercus macdougalii* Martínez, especie endémica de Oaxaca. Tesis de Maestría, Facultad de Estudios Superiores Iztacala, UNAM. 108 pag.

Pacheco-Cruz, N. 2022. Species Spotlight: *Quercus macdougalii* Martínez. International Oak Society. Available at <https://www.internationaloaksociety.org/content/species-spotlight-quercus-macdougallii-mart%C3%ADnez>



Ruiz-Aquino, F., Bautista, L. L., Bautista, A. E. L., Santiago-García, W., Pintor-Ibarra, L. F., and Rutiaga-Quiñones, J. G. 2020.

Anatomical characterization, physical, and chemical properties of wood of *Quercus macdougalii* Martínez, endemic species of the Sierra Juárez of Oaxaca, Mexico. *BioResources* 15(3): 5975-5998.

UNEP-WCMC and IUCN. 2023. Protected Planet: The World Database on Protected Areas (WDPA) [Online] Cambridge, UK. Available at [www.protectedplanet.net](http://www.protectedplanet.net). Accessed 2023.