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Research note

Especies del género *Quercus*, su distribución y volumen de madera en Tlaquilpa, Veracruz

Species of the *Quercus* genus, its distribution and timber volume in Tlaquilpa, Veracruz

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Resumen

La conservación de los bosques de encino en Veracruz demanda programas basados en el conocimiento de la ecología y distribución de las especies. Saber cuáles son los sitios que albergan a este género es una necesidad para seleccionar y priorizar las poblaciones por mantener. No obstante, aún se requiere de un esfuerzo más amplio en campo que permita identificar las localidades en las que crece cada taxón. El presente trabajo se realizó con el propósito de definir cuáles son las especies de encino que se distribuyen en el municipio Tlaquilpa, localizado en la Sierra de Zongolica, Veracruz, así como determinar sus volúmenes de producción maderable (m^3). Los resultados indicaron la presencia de seis taxa: *Quercus laurina*, *Q. crassifolia*, *Q. rugosa* que son de amplia distribución en el área de estudio, y alto volumen de producción maderable; mientras que, *Q. candicans*, *Q. glabrescens* y *Q. scytophylla* son de distribución más restringida y reúnen menor volumen. Los taxones identificados en el municipio tienen constante participación en las actividades productivas. No obstante, requieren de un programa de conservación para garantizar su continuidad ante las actividades humanas que disminuyen su potencial. Esta información es relevante no solo en los programas de conservación, sino también en las actividades de gestión forestal.

Palabras clave: Conservación de recursos forestales, encino, gestión forestal sostenible, producción maderable, Semarnat, Sierra de Zongolica.

Abstract

The conservation of oak forests in the state of Veracruz demands programs based on information about their species ecology and their distribution. Knowing which are the sites that harbor this genus is a necessity to select and prioritize the populations that must be protected. However, a broader effort is still required in the field to identify the locations where each species grows. The present work was carried out with the aim of defining which are the oak species that are distributed in the Tlaquilpa municipality at the Sierra de Zongolica, Veracruz, and their volumes of timber production (m^3). Results indicate that there are six species of oak: *Quercus laurina*, *Q. crassifolia*, *Q. rugosa*, which are widely distributed, and have a high volume of timber production; while *Q. candicans*, *Q. glabrescens* and *Q. scytophylla* have a more restricted distribution and gather less volume. The oak species identified in the municipality have constant participation in productive activities. However, they must have a conservation program to guarantee their permanence in the face of human activities that diminish their potential. This information is relevant not only in conservation programs, but also in forest management activities.

Key words: Forest resources conservation, oak, forest management sustainable, forest production, Semarnat, Sierra of Zongolica.

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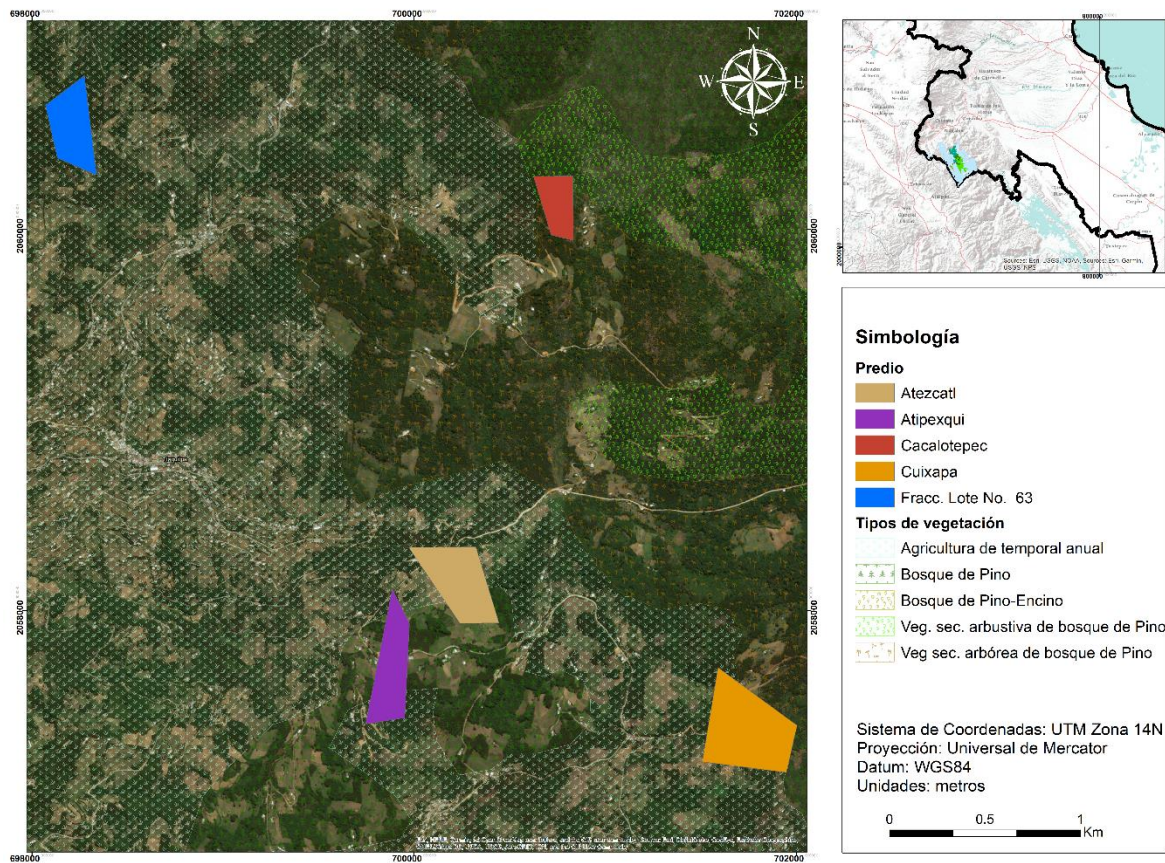
Around a third of the world's oaks are recorded in Mexico, 161 species, 109 of which are endemic; thus, this country is considered the largest center of *Quercus* diversity (Valencia-Á. and Gual-Díaz, 2004; Wehenkel *et al.*, 2017). They are distributed in a wide altitudinal range, from 0 to 3 100 m (Rzedowski, 1978), and make up oak, oak-pine and pine-oak forests in temperate, warm and semi-humid climates (Rodríguez and Romero, 2007); they are also present in the tropical evergreen forest, the mesophilic mountain forest and in the semi-arid zones (Rzedowski, 1978).

In the state of *Veracruz*, forests with oak species cover 55 974.9 ha (Márquez and Márquez, 2009). Although samplings have been made of this type of vegetation, in recent years new records have been made for the state, such as *Quercus furfuracea* (Liebm.) Oerst. (Castillo-Hernández and Flores-Olvera, 2017); therefore, it is necessary to continue with the determination of the species and their distribution sites. In the *Orizaba* and *Zongolica* mountain ranges there are extensive continuous areas, and fragments of important pine, oak and pine-oak forests (Gerez-Fernández and Pineda-López, 2011). This makes forest management important in these areas, and is part of the use of natural resources, which benefit the inhabitants through the extraction of wood and the production of ecosystem services.

For the *Quercus* genus, the *Tlaquilpa* region in the *Sierra de Zongolica* is an example of how illegal human actions affect forested areas, which are constantly altered by agricultural and livestock activities. In order to achieve its recovery, implementation of ecological restoration programs is necessary (Uribe-Salas *et al.*, 2018), based on the identification of species, distribution and other ecological characteristics, such as size structure, spatial distribution or regeneration. The natural interspecific distribution of the *Quercus* genus is not fully known in the area and there are areas that have not been studied. For this reason, the objectives that were proposed in this work consisted of determining the oak species and their distribution in farms of *Tlaquilpa*, *Veracruz*, and estimating the biomass per hectare of the forests in the sampled lands.

Field work was carried out in five properties in *Tlaquila*, *Veracruz*, a municipality located between 18°34' and 18°39' N and 97°02' and 97°09' W, at an elevation between 1 840 and 2 700 m. They cover 57.2 km², of which 29.6 km² are for

agriculture, 13.3 km² for forest and 14.4 km² for secondary vegetation (Figure 1); the climate is temperate humid with abundant rains in summer (94 %), temperate sub-humid with rains in summer (5 %) and semi-warm humid with rains all year round (1 %) (Sefiplan, 2016).



Simbología = Symbology; *Predio* = Property; *Tipos de vegetación* = Types of vegetation; *Agricultura de temporal anual* = Annual seasonal agriculture; *Bosque de pino* = Pine forest; *Bosque de pino-encino* = Pine-oak forest; *Veg. sec. arbustiva de bosque de pino* = Shrubby secondary vegetation of pine forest; *Veg. sec. arbórea de bosque de pino* = Secondary arboreal vegetation of pine forest; *Sistema de coordenadas* = Coordinate system; *Poyección* = Projection.

Figure 1. Geographical location of the sampled lands of the *Quercus* genus.

The collection of botanical samples was carried out in the properties located within the natural distribution of the *Quercus* genus, at different elevations (Table 1), for which it was considered that they were representative of the species that exist in the study area. The selected sites did not present severe forestry interventions and impacts on the vegetation, since they have been cared for by the owners of the land. The collected materials were labeled, dried and taken to the XAL Herbarium of the *Instituto de Ecología, A. C.* in *Xalapa, Veracruz* for their taxonomic identification.

Table 1. Collection sites for samples for *Quercus* in *Tlaquilpa, Veracruz*.

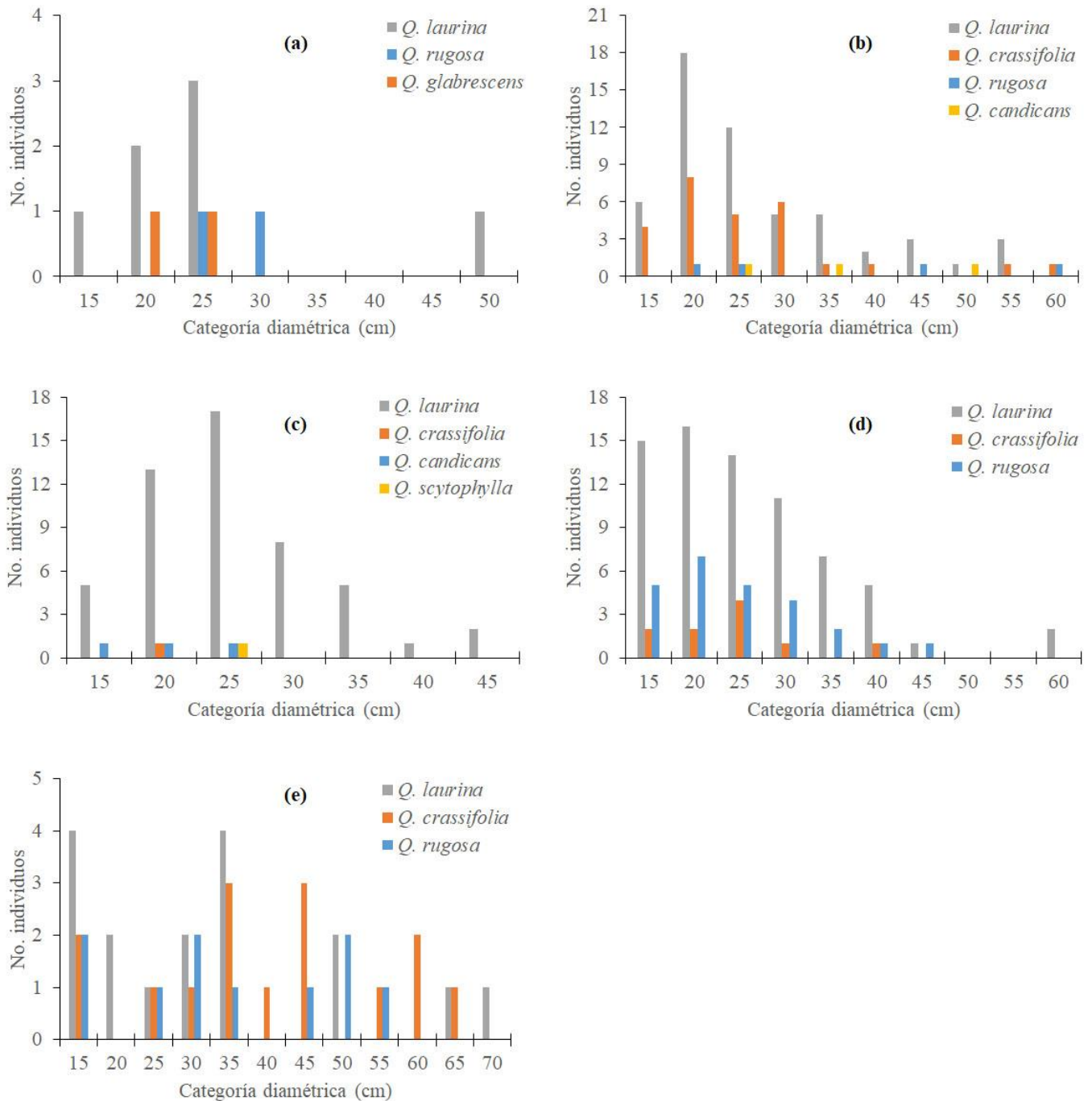
| Property | Latitude N | Longitude O | Elevation (m) |
|----------------------|-------------------|--------------------|----------------------|
| <i>Atipexqui</i> | 18°36'16" | 97°06'20" | 2 135 |
| <i>Atezcatl</i> | 18°36'23" | 97°06'17" | 2 186 |
| <i>Cuixapa</i> | 18°36'02" | 97°05'22" | 2 275 |
| <i>Frac. Lote 63</i> | 18°37'39" | 97°07'21" | 2 504 |
| <i>Cacalotepec</i> | 18°37'26" | 97°05'47" | 2 536 |

In each property the wooded area was calculated and sampling sites of variable dimensions were distributed in a systematic way [*i.e.* the site area depends, mainly, on the mean diameter of the trees to be inventoried and the basimetric area factor (SARH, 1985)], with a basimetric area factor of 1. At these sites, with the use of a simplified relascope the number of individuals that fulfilled the Bitterlich condition was counted, that is, only the trees whose normal diameter was fully or tangentially covered by the angle projection (SARH, 1985); total height was measured with a Haga altimeter, and the normal diameter (1.3 m from the base of the ground) and the basimetric area of each species, with a tree caliper. Based on this information, the timber stocks (m³) were determined in a traditional way by cubing each tree from

the height, diameter, basimetric area and morphic coefficient data. The latter were previously calculated by *Asesoría Forestal Especializada, A. C.*

Six oak species were identified, from which *Quercus laurina* Bonpl. (thin oak), *Q. crassifolia* Bonpl. (black oak) and *Q. rugosa* Née (yellow oak) recorded a greater range of distribution; while *Q. candicans* Née (oak oak), *Q. glabrescens* Benth. (*ahuehuete* oak) and *Q. scytophylla* Liebm. (ash oak) had a more restricted distribution (Figure 2). It was observed that *Q. laurina* was present in all the properties (trees of 15 to 70 cm in diameter), while *Q. rugosa* and *Q. crassifolia* in four (trees of 15 to 60 and 15 to 65 cm in diameter, respectively); on the other hand, *Q. candicans* was identified in two (trees of 15 to 50 cm in diameter), and *Q. glabrescens* and *Q. scytophylla* only in one (trees of 20 to 25 and 25 cm in diameter, respectively).





No. de individuos = Number of individuals; *Categoría diamétrica* = Diameter category.

Figure 2. Density of individuals by diameter category of *Quercus* species in sites in Tlaquilpa, Veracruz: (a) Atipexqui, (b) Atezcatl, (c) Cuixapa, (d) Frac. Lot 63 and (e) Cacalotepec.

In Figure 2 is observed that there are individuals of *Q. laurina*, *Q. rugosa* and *Q. crassifolia* in the defined diameter categories (15 to 70 cm) but most were concentrated in the first four (15 to 30 cm), while *Q. candicans*, *Q. glabrescens* and *Q. scytophylla* remained in the minor categories (15 to 35 cm); therefore, small diameter classes predominated in the sampled properties. This implies that the sampled oak populations have regenerated more trees, and are currently characterized by the population pyramid of natural forests (Morgenstern, 1996) which corresponds to more young trees and fewer mature trees.

The species had different volumes per hectare (Table 2), being *Q. laurina*, *Q. rugosa* and *Q. crassifolia* the ones with the highest total production (476.047, 245.016 and 143.147 m³, respectively), and *Q. candicans*, *Q. glabrescens* and *Q. scytophylla* the smallest (26.881, 10.784 and 3.210 m³, respectively).



Table 2. Biomass of *Quercus* species in five farms in *Tlaquilpa, Veracruz*.

| Property | Stand-Substand | Area (ha) | Species | A.B. (m ² ha ⁻¹) | ERT [¶] (m ³) |
|----------------------|----------------|-----------|-----------------------|---|------------------------------------|
| <i>Atipexqui</i> | I-1 | 0.7200 | <i>Q. laurina</i> | 7.000 | 41.460 |
| | | | <i>Q. rugosa</i> | 2.000 | 12.873 |
| | | | <i>Q. glabrescens</i> | 2.000 | 10.784 |
| <i>Atezcatl</i> | II-1 | 0.5872 | <i>Q. laurina</i> | 3.000 | 24.095 |
| | | | <i>Q. rugosa</i> | 1.333 | 7.380 |
| | | | <i>Q. crassifolia</i> | 8.500 | 63.637 |
| | | | <i>Q. candicans</i> | 0.833 | 3.146 |
| | II-2 | 0.6672 | <i>Q. rugosa</i> | 22.000 | 158.974 |
| <i>Cuixapa</i> | III-1 | 0.6834 | <i>Q. laurina</i> | 13.500 | 106.656 |
| | | | <i>Q. crassifolia</i> | 1.000 | 7.088 |
| | | | <i>Q. candicans</i> | 2.000 | 15.062 |
| | III-2 | 1.0032 | <i>Q. laurina</i> | 14.500 | 103.960 |
| | | | <i>Q. candicans</i> | 1.000 | 8.673 |
| | | | <i>Q. scytophylla</i> | 1.000 | 3.210 |
| <i>Frac. Lote 63</i> | IV-1 | 0.4563 | <i>Q. laurina</i> | 13.330 | 75.266 |
| | | | <i>Q. rugosa</i> | 4.167 | 20.370 |
| | | | <i>Q. crassifolia</i> | 4.667 | 25.009 |
| | IV-2 | 1.4356 | <i>Q. laurina</i> | 13.000 | 86.499 |
| | | | <i>Q. rugosa</i> | 5.500 | 36.832 |
| | | | <i>Q. crassifolia</i> | 2.000 | 13.257 |
| <i>Cacalotepec</i> | V-1 | 0.8557 | <i>Q. laurina</i> | 3.125 | 11.759 |
| | | | <i>Q. rugosa</i> | 2.000 | 8.587 |
| | | | <i>Q. crassifolia</i> | 3.250 | 20.380 |
| | V-2 | 0.6755 | <i>Q. laurina</i> | 3.000 | 26.352 |
| | | | <i>Q. crassifolia</i> | 2.000 | 13.776 |

¶ERT = Timber production, estimated from the height, diameter, basimetric area and morphic coefficient data.

Based on Table 1, *Q. laurina*, *Q. rugosa*, *Q. crassifolia* and *Q. candicans* are distributed in most of the gradient analyzed (2 135 to 2 536 m asl), while *Q. glabrescens* and *Q. scytophylla* only in one part of it (2 135 and 2 275 m asl, respectively). It has been determined that the distribution of the genus is positively associated with topographic heterogeneity (Uribe-Salas *et al.*, 2018), in particular *Q. laurina* has the greater abundance at higher elevations (Huerta *et al.*, 2014). Oak species are also influenced by latitude, which has been shown to have a correlation with their morphological traits, such as leaf size reduction (Uribe-Salas *et al.*, 2008). Despite the importance of elevation and latitude on the occurrence and variation of oak species, the climatic variables of the place also play a relevant role and, consequently, significantly influence the presence of the genus in different sites.

From the distribution potential that it has in the state of *Veracruz*, it is possible that *Q. laurina* recognizes favorable conditions to be maintained in places of low humidity due to the effect of climate change, which will allow it to be preserved in the future (Estrada-Contreras *et al.*, 2015). Other species with this ability to adapt are *Q. crassifolia* and *Q. rugosa*, since they are moderately sensitive to this phenomenon (Galicía *et al.*, 2015).

The study area stands out for being included within the states of the country and the regions with the greatest wealth of oaks of the Transverse Neovolcanic Axis (*i.e.*, region V) (Luna-José *et al.*, 2003; Valencia-Á. and Gual-Díaz, 2014). The number of oak species and their density of individuals, influence the ecosystem processes of the site where they grow and allow a high diversity of epiphytic plant species, such as lichens (Pérez-Pérez and Guzmán, 2015), animals such as arthropods (Maldonado-López *et al.*, 2018), fungi and bacteria (Valencia-Á. and Gual-Díaz, 2014). However, this potential is constantly threatened by anthropogenic activities such as the agricultural crops (Pérez-Pérez and Guzmán, 2015) or the change of land use for urban purposes (Flores *et al.*, 2018).

On the other hand, the oak species identified in this work are also very important in the production of other types of goods that are carried out legally in the evaluated

properties. For example, *Q. laurina* and *Q. crassifolia* provide firewood and raw material for the elaboration of charcoal, and their wood has adequate chemical properties as a fuel source, due to its high heating value (Ruiz-Aquino *et al.*, 2015). It has been estimated that the consumption of charcoal in the country will increase from 1 to 158 % in 2030 (Serrano-Medrano *et al.*, 2014), so one option could be to increase the wooded areas of oak species and promote their sustainable in *Tlaquilpa*, *Sierra de Zongolica*, *Veracruz*. Other general management characteristics that highlight the importance of oaks are their medicinal and edible use (*Q. candicans*, *Q. crassifolia* and *Q. rugosa*), leather tanning (*Q. candicans* and *Q. crassifolia*), handicrafts (*Q. candicans*) and forage (*Q. candicans*, *Q. glabrescens*, *Q. laurina* and *Q. rugosa*) (Luna-José *et al.*, 2003).

In the state of *Veracruz*, vegetation samples have been carried out to identify oak species, which are of ecological importance in the regions where they are distributed. However, there are still records that have found unregistered species, so it is necessary to continue this work in areas that have not been fully sampled. In *Tlaquilpa* there are six taxa, of which *Quercus laurina*, *Q. crassifolia* and *Q. rugosa* have a wider distribution and greater biomass than *Q. candicans*, *Q. glabrescens* and *Q. scytophylla*. These species participate in forest production in the area differently, so it is a priority to propose programs for their conservation in the face of human activities that diminish their potential, e.g. ex. change of land use for the production of agricultural crops.

The knowledge generated in this work is relevant for the formulation of conservation programs and for the direction of forest management activities. It is recommended to carry out further studies on different ecological aspects (*i.e.*, regeneration, demographics) of the six determined species in order to understand the viability of their present and future populations.

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Conflict of interest

The authors declare no conflict of interest.

Contribution by author

Andrés Flores: work planning, structuring, data analysis and writing of the manuscript;
Jesús Octavio Romero García: work planning and supervision of the investigation.

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