

The Oaks of the Mexican Bajío

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The ever-increasing pace of destruction of our cultural and natural heritage is one of the most striking evils of our time. Today's processes of desertification, deforestation, ecosystem fragmentation and its possible effect on global climate change, are of incomparable scope.

Significant changes in land use have had an important impact on Mexican forests - the immediate result of which has been the disappearance of a considerable portion of our natural resources and the massive loss of an innumerable quantity of goods and services derived from these ecosystems.

In Mexico the recognition of protected areas does not contribute substantially to conservation efforts for many reasons: insufficient surveillance, illegal logging, damage due to forest fires, plagues and diseases, illegal hunting, farming and livestock. There are also land conflicts, relocation of entire communities and finally, greater poverty due to restrictions on use of and access to natural resources.

Mexico needs to revise its national forest conservation strategy. It should consider an alternative strategy based on real and widespread local community participation. Serious processes need to be engaged to empower internal institutions and legal instruments and to strengthen our social resources. Only in this way can conservation of natural resources be successful.

Description of the Bajío and Adjacent Regions

The area called the Bajío and adjacent regions, is in the center of Mexico, according to Rzedowski. It comprises the entire states of Querétaro and Guanajuato and that portion of north Michoacán east of the 102°10'W meridian and, to the north, by the Cuenca del Rio Balsas. With these borders, the region represents about 50,000 km² (Rzedowski *et al.*, 1991).

Physiography and Surface Geology

The region defined as the Bajío and adjacent regions contributes to three of Mexico's physiographical regions : the Altiplanicie Mexicana, the Sierra Madre Oriental, and the Eje Neovolcánico.

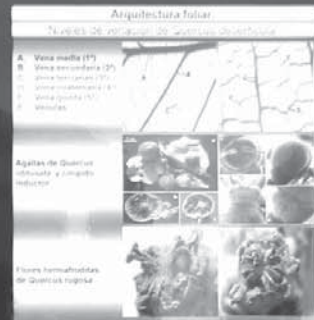
The Altiplanicie Mexicana includes nearly the entire state of Guanajuato, and a large part of the centre of Querétaro, in addition to a large section of the north of Michoacán; it is bordered by the Sierra Madre Oriental in the northeast and by the Eje Neovolcánico in the south.

Physiographically, it is formed by extensive and nearly flat (or of insignificantly sloped) areas interrupted by dispersed mountain chains of varying elevation and



Los encinos (*Quercus*, Fagaceae) del Bajío Mexicano: morfología y distribución

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El género *Quercus*, el más grande de la familia Fagaceae, incluye alrededor de 500 especies en todo el mundo. Nixon (1993) reconoce para este taxa dos subgéneros: *Quercus* y *Cyclobalanopsis*; al subgénero *Quercus* lo divide en tres secciones: *Lobatae*, *Protobalanus* y *Quercus*. En México están representadas estas tres últimas; Rzedowski (1978) estima que podría haber 150 a 200 y Nixon (1993) dice que existen de 135 a 150, de las cuales más de la mitad (86) son endémicas.

En México se encuentra un centro de diversificación del género; sin embargo, muchas de las especies no son bien conocidas y los bosques donde habitan ya han desaparecido o presentan diferentes grados de deterioro.

El objetivo de este trabajo fue reconocer las especies que habitan en el Bajío Mexicano, describir su morfología y sus características ecológicas, elaborar una clave de identificación y hacer consideraciones sobre su distribución y conservación. Para ello se hizo la revisión de los herbarios ENCB, IEB, EBUM, se realizaron salidas al campo y se estudiaron los ejemplares tipo. También se estudió la propagación de 19 taxa. Se encontraron 43 especies, 20 de la sección *Lobatae* y 23 de la sección *Quercus*; de ellas 24 son endémicas de México y 11 habitan en Guatemala, Centroamérica y/o EUA. Se consideran 23 especies como muy escasas en el Bajío.

Especie	Distribución	Abundancia	Tipo de Vegetación	Altitud (m s.n.m.)
<i>Q. affinis</i>	Norte y centro de México	abundante	BQ, BQP, BMM, MX	1700-2500
<i>Q. candicans</i> **	México y Guatemala	abundante	BQ, BQP, BMM	2000-3500
<i>Q. castanea</i> →	México y Guatemala	muy abundante	BQ, BQP, P, MX	1000-2500
<i>Q. conspersa</i>	México y Guatemala	muy abundante	BQ, BQP, BMM	1700-2300
<i>Q. crassifolia</i> →	Sureste, Centro y sur de México	muy abundante	BQ	2300-2400
<i>Q. crassipes</i> →	Centro sur de México	muy abundante	BQ, BQP, BMM	2100-2800
<i>Q. deserticola</i>	Centro sur de México	abundante	BQ, BTC	1100-2700
<i>Q. dilytophylla</i> →	Centro sur de México	muy abundante	BQ, BQP, BMM	2100-2400
<i>Q. eduardii</i>	Centro sur de México	escasa	BQ, BQP, BQI, P	1700-2700
<i>Q. frutescens</i> →	Centro sur de México	escasa	BQ, BQP, MX, P	2100-2900
<i>Q. gentryi</i>	Noreste, centro y sur de México	muy abundante	BQ, BQP, BMM, BTC	2100-2600
<i>Q. germana</i> →	Noreste y centro sur de México	muy abundante	BQ, BQP, BMM	700-2300
<i>Q. glabrescens</i>	Centro sur de México	muy abundante	BQ, BQP, BTC	2000-2800
<i>Q. glaucescens</i>	Noreste y centro sur de México	muy abundante	BQ	1300-1400
<i>Q. glaucoides</i>	Centro sur de México	escasa	BQ, MX	1900-2200
<i>Q. greggii</i> →	Noreste y centro sur de México	escasa	BQ, MX	2500-3300
<i>Q. grisea</i> →	EUA y México	escasa	BQ, MX, P	1700-2600
<i>Q. jonesii</i>	Norte y centro sur de México	muy abundante	BQP	1200-2400
<i>Q. laeta</i> →	Norte y centro sur de México	muy abundante	BQ, BQP, BQI, MX	1100-2400
<i>Q. laurina</i> ** →	México y Guatemala	muy abundante	BQ	2240-2800
<i>Q. magnifolia</i>	Noreste y centro sur de México	muy abundante	BQ, BQP, BTC	1500-2400
<i>Q. marimezli</i>	Centro sur de México	muy abundante	BQ, BQP	2000-2100
<i>Q. mesicana</i> →	Noreste, centro y sureste de México	muy abundante	BQ, BQP, BQI, BMM, MX	1600-2700
<i>Q. microphylla</i> **	Norte y centro sur de México	abundante	MX	1600-2400
<i>Q. obtusata</i> →	Centro de México	muy abundante	BQ, BQP, BMM, BTC, P, MX	1700-2600
<i>Q. olivoides</i>	México a Costa Rica	muy abundante	BQ, BTC	240-280
<i>Q. pedunculata</i>	Centro sur y sureste de México	muy abundante	BQ	2500-2600
<i>Q. pinnatifida</i> **	Noreste y centro sur de México	muy abundante	BQP, BMM	650-2000
<i>Q. planipocula</i>	Noreste y centro sur de México	muy abundante	BTC	200-1300
<i>Q. polymorpha</i>	CLM, México y Guatemala	muy abundante	BQ, BMM, BTC, MX	200-1700
<i>Q. potosina</i>	Noreste y centro sur de México	muy abundante	MX, BQ, P	1800-2100
<i>Q. prinoides</i> **	Noreste y centro sur de México	muy abundante	MX	2410
<i>Q. repanda</i> **	Noreste y centro sur de México	muy abundante	MX, BQ	2500-3000
<i>Q. resinosa</i>	Noreste y centro sur de México	escasa	BQ, BQP, BQ	1300-2100
<i>Q. rugosa</i> ** →	Norte, Centro, sur y sureste de México	muy abundante	BQ, BQP, BMM, P	2000-2000
<i>Q. rycophylla</i>	Noreste y centro sur de México	muy abundante	BQ, BQP	700-1000
<i>Q. satcufolia</i> **	México a Panamá	muy abundante	BQP	2300
<i>Q. scytophylla</i> →	Noreste, centro sur y sureste de México	muy abundante	BQP	1900-2300
<i>Q. sideroxylla</i>	Norte y centro sur de México	muy abundante	BQ, BQP	2400-2600
<i>Q. subspatulata</i>	Noreste y centro sur de México	muy abundante	BQ, BQP	1700-2600
<i>Q. subserotata</i>	Noreste y centro sur de México	muy abundante	MX	1800-2000
<i>Q. viminea</i>	CLM y México	muy abundante	BQ, MX	1700-1800
<i>Q. xalapensis</i> →	Noreste, centro y sureste de México	abundante	BQ, BQP, BMM	1100-2400

La mayor parte de los taxa se encuentran en bosques de *Quercus* (BQ) y mixtos de *Pinus-Quercus* (BQP), también habitan, en bosque mesófilo de montaña (BMM), matorral xerófito (MX), pastizales (P), bosque tropical caducifolio (BTC) y de galería (BG). El intervalo altitudinal que ocupan es de 240 a 3300 m, la mayoría se distribuye entre los 1100 y 2800 m. Cuatro taxa son arbustivos y el resto tiene tallos de 5 a 35 m de alto y 0.30 a 1.50 m de diámetro. Sus hojas miden 3 a 25 cm de largo con diferentes texturas y colores; el largo de los frutos es de 6 a 38 mm.

Los caracteres diagnósticos se encuentran en el margen de las hojas, densidad y color de indumento de ramillas y hojas, tipo de tricomas, superficie de epidermis, y tamaño, forma, consistencia y color de hojas.

En vivero se han propagado con éxito 19 especies, obteniéndose altos porcentajes de germinación y sobrevivencia; además el crecimiento en vivero permite obtener plantas de 80-150 cm de alto en 1-2 años. A pesar de esto no existen programas de producción a gran escala de encinos con fines de restauración y conservación.



size. In this region, the altitude measures between 1700 and 3300 m. Considering the altitude of the plains as reference, a slightly higher-elevation zone can be found in the northern part and one with a lower elevation in the south.

Climate

The physiographical contrasts of the Bajío and adjacent regions contribute to the presence of many climatic variants. In general, the dominant climates are characterised by the same conditions present in many places in Central Mexico. For example, the rainy season is mainly from (May) June to October, daily temperature fluctuations are always more important than the annual ones, the coldest month is December or January and the hottest, May or June, sunshine is generally very intense, winds are moderate and length of day of little variation (Zamudio *et al.*, 1992).

Average annual temperatures vary generally between 9° C and 24° C, except at high altitudes in the mountains where they can be lower and, at lower altitudes, such as in canyons or along rivers, where they can be higher. A heating phenomenon exists in this region, probably due to topography, that explains why, in this region, temperatures are higher than in other regions of Mexico of similar altitude (Rzedowski & Calderón de Rzedowski, 1987).

Average rainfall varies from 350 to a little more than 1200 mm, but for a vast part of the region it is more generally between 450 and 800 mm.

The climates found in the *Bajío* and adjacent regions belong to various different categories of the types C, B and A of Köppen's classification, modified by García (1973). The geographical distribution of these different climates corresponds roughly to altitude.

Vegetation

As a function of the physiographical, geological and climatic diversity, the vegetation of the Bajío and adjacent regions appears as a varied mosaic. In an unpublished document (Zamudio *et al.*, unpublished) as well as in Zamudio *et al.* (1992), using the classification proposed by Rzedowski (1978) the following types can be found :

Coniferous forest. In the area studied, these are found between 1100 and 2850 m, cover approximately 10.5% of the region's surface and are represented by *Pinus* L., *Juniperus* L., *Cupressus* L. and *Abies* Mill., forest.

***Quercus* forest.** Oak forests start at about 800 m and can be found at elevations up to 2800 m, in a number of different environments that go from semi-arid to humid. Their floristic composition is diverse and they form communities of medium to very tall trees. In certain parts they are interspersed with *Pinus* forest and in others, mixed with forest of *Juniperus*, *Cupressus* and *Abies*. They cover about 14.5% of the region.

***Quercus-Pinus* forest.** These are plant communities that are always green; even if deciduous elements are frequently present. These are found at altitudes from between 800 to 3300 m principally in canyons or on slopes protected from the sun. These forests are floristically diverse and varied.

Mesophytic mountain forest. This formation covers very restricted areas, and most of it can be found in the extreme north-east of Querétaro, in humid canyons and slopes at altitudes from 800 to 2700 m.

Deciduous tropical forest. This kind of vegetation can be found between 300 and 2200 m, on shallow, rocky well drained soil of igneous or sedimentary origin.

Xerophytic scrub forest. In the arid and semi-arid areas of the region studied various different scrub communities can be found, at altitudes from 600 to 2500 m.

Pasture. Pastures are common in the center and the north of Guanajuato and scarce in the other areas of this study. They occupy areas that are slightly sloped or flat, between 1500 and 3000 m.

The genus *Quercus* L., the largest of the family *Fagaceae*, includes about 500 species worldwide. Nixon (1993) recognizes two subgenera for this taxa, *Quercus* and *Cyclobalanopsis* Oerst., with the subgenus *Quercus* subsequently divided into three sections, *Lobatae* Trel., *Protobalanus* (Trel.) A. Camus and *Quercus*. Representatives of all three sections of the subgenus *Quercus* can be found in Mexico. Rzedowski (1978) estimated between 150 and 200 species in Mexico and Nixon (1993), between 135 and 150, of which more than half (86) are endemic.

Mexico is a center of diversity for the genus; nevertheless many of the species are not well known and the forests where they grow have already disappeared or are at various different stages of deterioration.

The objective of this study was to identify the species of the Bajío Mexicano, describe their morphology and ecological characteristics, develop a species identification key and formulate thoughts on distribution and conservation. To achieve this, the herbaria ENCB, IEB, EBUM and IZTA were reviewed, field trips were made and type specimens were studied. In addition, nursery propagation was studied for 19 taxa.

In the region studied, 43 species of *Quercus* can be found: 20 in the section *Lobatae*, and 23 in the section *Quercus*. Of these, 34 are endemic to Mexico and 11 can be found also in Guatemala, Central America and/or the United States.

Of the more abundant species (*Q. castanea* Née., *Q. crassifolia* Bonpl., *Q. crassipes* Bonpl., *Q. laurina* Bonpl., *Q. mexicana* Bonpl., *Q. obtusata* Bonpl., *Q. polymorpha* Schldl. & Cham. and *Q. rugosa* Née) many of them have a wide distribution in Mexico as they are found as components in many different vegetation types.

23 species are considered very scarce. Some of these are: *Q. gentryi* C.H. Mull., *Q. germana* Schldl. & Cham., *Q. glabrescens* Benth., *Q. glaucoides* M. Martens & Galeotti, *Q. glaucescens* Bonpl., *Q. magnoliifolia* Née, *Q. martinezii* C.H. Mull., *Q. pinnativenulosa* C.H. Mull., *Q. peduncularis* Née, *Q. planipocula* Trel. and *Q. repanda* Bonpl.

The majority of the taxa are found in *Quercus* forest and mixed *Pinus-Quercus* forest although they can also be found in mesophytic mountain forests and xerophytic scrub, rarely in pastures, deciduous tropical as well as riparian forests. Generally speaking, all of the *Bajío* vegetation types where oaks are

present are, to different degrees, in a disrupted state.

Without a doubt, it is the mesophytic mountain forest that will have to owe its disappearance to the intense human activity to which it is subjected through overgrazing and seasonal agriculture. This has led to a situation where its distribution has been reduced to the steepest and least accessible areas. This type of vegetation is host to about 15 *Quercus* species.

These species occupy the altitudinal interval between 240 and 3300 m, with the majority distributed between 110 and 2800 m. 14 species can be found at elevations higher than 2000 m; (*Q. candicans* Née, *Q. crassifolia*, *Q. dysophylla* Benth., *Q. gentryi* C.H. Mull., *Q. glabrescens*, *Q. greggii* (A. DC.) Trel., *Q. rugosa*, etc.); 7 lower than 2000 m (*Q. viminea* Trel. and *Q. polymorpha*) and 2 are found at elevations below 1000 m. Thus we find *Q. oleoides* Schltld. & Cham. and *Q. pinnativenulosa* between 240 and 280 m while we find *Q. repanda* and *Q. greggii* between 3000 and 3300 m above sea level.

4 taxa are shrubs (*Q. frutex* Trel., *Q. microphylla* Née, *Q. pringlei* Seemen ex Loes., and *Q. repanda*) and the remainder can be from between 5 and 35 m tall trees with diameters of 0.30 to 1.50 m. 20 species measure, in height, from between 15 and 25 m, 8 less than 10 m and 9 from 5 to 15 m. The tallest species are *Q. rugosa*, *Q. salicifolia* Née, *Q. candicans*, *Q. laurina* and *Q. pinnativenulosa*, that can attain heights of up to 30-35 m.

In general, the Bajío species have leaves that measure from 3 to 25 cm in length with different textures and colors; while *Q. magnoliifolia* has leaves that can be up to 25 cm long, *Q. pringlei* has leaves of 3 cm or less. Fruit length varies from 6 to 38 mm; the species with the largest acorns, as much as 38 mm long, is *Q. germana*, and those with the very smallest of acorns are *Q. castanea*, *Q. gentryi* and *Q. pringlei*.

The diagnostic characteristics taken into consideration to formulate the species key were leaf edge, the density and color of twig and leaf tomentum, trichome type, epidermis size and surface, leaf shape, consistency and color; and also, acorn dimensions and shape.

The species descriptions include general leaf architecture models as well as traditional characteristics.

Exhibiting high germination and survival rates, 19 species of the Bajío have been propagated with success in nurseries. Amongst these are: *Q. candicans*, *Q. crassifolia*, *Q. crassipes*, *Q. dysophylla*, *Q. frutex*, *Q. germana*, *Q. greggii*, *Q. peduncularis*, *Q. polymorpha*, and *Q. rugosa*. In 1 to 2 years, plants of between 80 and 150 cm were obtained. The acorns used for this were collected in the Bajío and elsewhere.

Despite the fact that there exists sufficient information for large scale production of different species for purposes of conserving these taxa and vegetation types, there are no programs that take into account the necessity to propagate specific species suited to specific localities. There are nurseries that grow oaks for reforestation but most of them don't know the species they are propagating and even fewer if they are the adequate species for the areas in which they will be planted. Attempts were made to work with CONAFOR; however, the cost they estimate per plant is extremely low and would not cover costs of collection and propagation. In addition they are only interested in working with

one or two species, with no consideration as to the adequacy of these species for the different areas to be planted.

The Laboratorio de Ecología y Taxonomía de Árboles y Arbustos (The Laboratory of Tree and Shrub Ecology and Taxonomy) has undertaken studies of oaks in other areas as well

- **Community structure.** Information has been obtained on the structure of oak communities in 16 different municipalities in the State of Mexico.
- **Nursery propagation.** To date we have studied the germination and growth behaviour of approximately 25 species. We have also investigated growth of certain species in relation to varying substrates and soils.
- **Species reintroduction.** To date, 20 different species have been planted in different municipalities in the States of Mexico and Hidalgo. Currently, growth and survival rate are being monitored as are phytosanitary condition and phenology.
- **Oak galls.** We are in the process of collecting galls, the insects and the host species. Our recent investigations in this area have led to the description of a new genus and species of insect (a Cinipid wasp).
- **Flower morphology.** Although our work in this area is very young, I consider it important to mention that we have identified hermaphroditic flowers in *Quercus glaucoides* and *Q. rugosa* in Michoacán and in the State of Mexico. We have described the morphology and presented photographs and drawings obtained with a scanning electron microscopic.
- **Karyology.** 8 species have been studied to determine the karyotype (*Q. candicans*, *Q. crassifolia*, *Q. elliptica* Née, *Q. hintonii* E.F. Warb., *Q. urbanii* Trel., *Q. frutex*, *Q. obtusata*, *Q. rugosa*). In all cases, they are diploids ($2n = 2x = 24$) with slightly asymmetrical karyotypes.
- **Leaf architecture.** 25 species have been studied for leaf architecture including stomate morphology and stomatic index. This kind of information yields diagnostic characteristics that are extremely useful in species identification.

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