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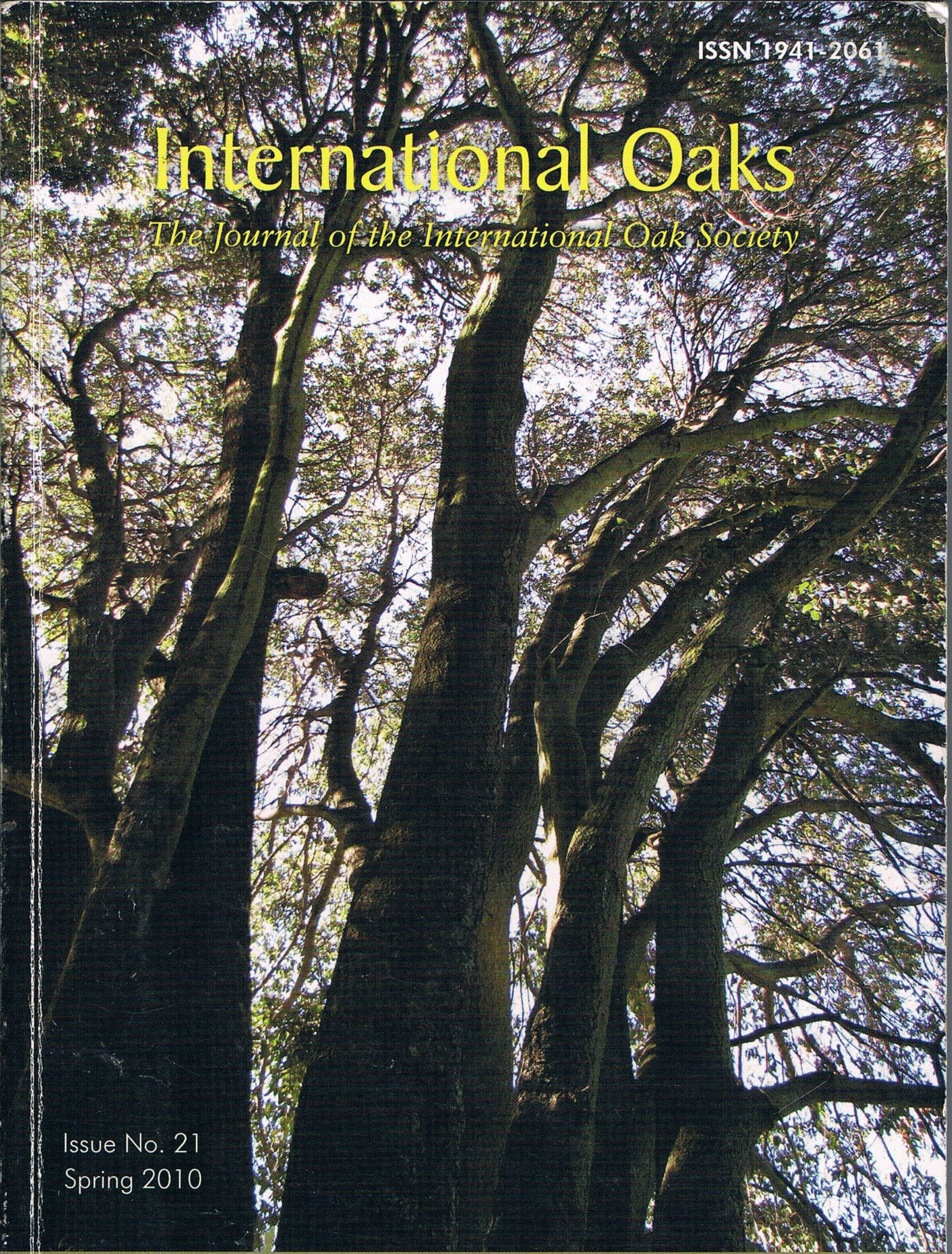
International Oaks

The Journal of the International Oak Society



Issue No. 21
Spring 2010

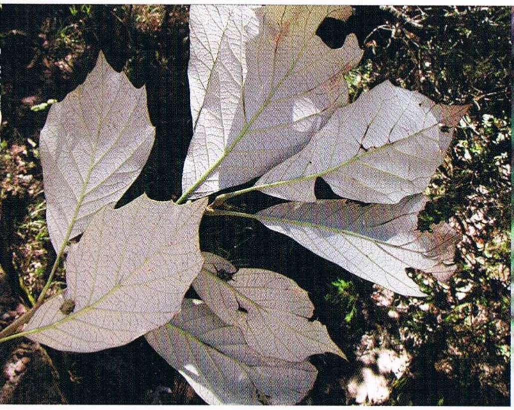
PROCEEDINGS

Sixth International Oak Conference

Fall 2009 • Puebla, Mexico

Quercus crassipes *Quercus obtusata*

Quercus affinis *Quercus urbanii*



INTERNATIONAL OAKS

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Puebla, Mexico

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The International Oak Society

Anyone interested in joining the International Oak Society or ordering information should contact the membership office or see page 200 for the membership enrollment form. Benefits include *International Oaks* and *Oak News and Notes* publications, conference discounts, and exchanges of seeds and information among members from approximately 30 nations on six continents.

International Oak Society Website:
http://www.internationaloaksociety.org

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Cover photos:
Front: *Quercus crassipes* seen during the tour in Guerrero
photo©Guy Sternberg

Back: *Quercus rugosa, Quercus corrugata, Quercus insignis*
photo©Guy Sternberg

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Message from the President

Mexico.
A word that conjures up images of extraordinary trees:
Quercus acherdophylla, Q. magnoliifolia, Q. corrugata, Q. insignis…
growing in places with extraordinary names:
Tlaxcala, Acaxochitlan, Zacacuautla, Huautusco…
vaguely evocative, if only in their sound, of gold, chocolate, mysterious birds
and fierce heavens that have ceased being.

Mexico shares with only one other place in the world what appears to be an inextinguishable number of *Quercus* enigmas and surprises. Although understandably difficult to organize, I hope that this first IOS conference in Mexico is not the last. We have seen only a very small part of Mexican *Quercus* diversity, on the one hand, and, on the other, it is particularly appropriate that our Society provide a platform for Mexican researchers to present their work and make known their opinions about conservation policies and activities. I heartily encourage other plant societies to make this country their venue for field trips, conferences, etc...

An undeniably essential component of the success of the IOS Conference in Mexico was Dr. Maricela Rodríguez-Acosta. Equally, but more importantly, she is an invaluable part of Mexican research and conservation efforts in general and of *Quercus*-related projects in particular. The International Oak Society is indebted to Maricela, her students and entire team for we now have a new quality standard by which to set our sights for future conferences.

The first International Oak Society US event in 2010 will be at the UC Davis Arboretum Shield Oak Grove (2 May 2010). How fitting in light of an "oak" event that has marked the start of this new decade : the discovery by, amongst others, UC Davis researcher Jeffrey Ross-Ibarra, of the Jurupa Hills oak, a 13,000 year-old (clonal) *Quercus palmeri* Engelm. in Riverside County. This event is organised by Emily Griswold (UC Davis Arboretum, Horticultural Curator), who can be contacted at ebgriswold@ucdavis.edu to sign up for the VIP tour that is planned for IOS members.

The first European event in the new year, organized by Shaun Haddock (France), will be a guided tour to Kew Gardens (London) in the summer of 2010. In *Plant Hunting For Kew* (HMSO, ed. F. Nigel Harper, 1989), accounts of botanic expeditions all over the world (including Mexico) remind us of the importance of visiting the world to discover and propagate the plants that are our passion.

Which ones will germinate? which not? which species will produce the healthiest seedlings? what surprises await us in terms of hardiness? or frost-tenderness? For those of us growing oaks, these are the exciting things we have now to think about. Indeed, depending on the publication date of this journal, some of these questions will have been resolved and our thoughts already turned to future planting possibilities, and, of course, towards our next adventure.

Béatrice Chassé

Quercus corrugata photo©Maricela Rodríguez-Acosta

Quercus sebifera photo©Allen Coombes

Oaks of Puebla

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Origins of the oak collection in Puebla

One of the most frequent questions we are asked about oaks is why do we call them encinos in Spanish? To answer this we have to talk about *encina*, the Spanish name for *Quercus ilex* L., which comes from *lecina* derived from *ilicina* (Latin for *Quercus ilex*).

Another question we have to answer very often is why do we like oaks, and we then talk about history, as many of them can reach a thousand years old, such as *Quercus robur* L. An example of this is the Majesty Oak at Fredville House, Kent, UK which currently has a 12 m circumference.

Our experiences with oaks go back to 1992 when we started to propagate oaks and later on they were reintroduced in patches of a private land located in Valsequillo Valley. It was in 1995 that we were involved with a wider project, and 200,000 oaks were propagated for a government office named SEDESOL for planting in different regions in Puebla. Propagating such a number of plants in a region where water is a limiting factor was a very difficult task.

It was then when we started the project to develop an oak national collection devoted to hold as many oaks species as possible. Several field trips were organized and the national collection was placed in two gardens: Louise Wardle de Camacho, the Botanic Garden at Africam Safari (LWC) and a duplicate in the Botanic Garden at the Benemerita University Autonoma de Puebla (Rodriguez-Acosta, 1995).

In 1999, the oak collection held 75 Mexican species (LWC), all of them in the nursery, but unfortunately they were not planted on time and by 2002 there were many losses reducing the species number considerably. By that time the Botanic Garden at Benemerita University of Puebla was growing and many of the oaks introduced as part of the collection were prospering and well established, making it today the best oak collection in Mexico.

Oak Conservation

Oak forests in Mexico have been strongly affected by human population mainly as a source of fuel as firewood and charcoal, and compost for gardens. As a result, the central part of Mexico has seen its oak forests severely reduced, and the same situation applies to more tropical areas in Mexico.

For example, Puebla state has lost 90% of its oak forest in two decades (Rodriguez-Acosta, 2009). 44 Mexican species were reported as potentially threatened (Walter & Gillet, 1998) from which 13 are Data Deficient, 19 are considered Rare, 7 Vulnerable, and 5 more Endangered. With this information and with financial support from IUCN, in 1999 a project was started to determine the exact status of *Quercus hintonii* E.F. Warb. (Rodríguez-Acosta & Coombes, 2000). Following this, we were able to reduce the category of this species from Critically Endangered to Endangered as it was found to occur over a much wider area than was originally believed.

In 2002, a new project was started devoted to assess the distribution of *Q. insignis* M. Martens & Galeotti, which has its main populations in the Huatusco area in Veracruz state and several locations in Jalisco. We concluded that this species was at greater risk in Jalisco as the water sources there were decreasing in the natural habitat of this species.

These two studies highlight the need for time and money for a complete assessment of the Mexican species and at the same time showed that the best way to protect our oak species was by conserving the forest.

Oak diversity in Puebla

Puebla state is large and diverse and includes almost all the habitats in Mexico with exception of the coast. It includes the two highest volcanoes Citlaltepetl and Popocatepetl and lowlands only 50 meters above sea level. This range gives a higher oak diversity than we originally thought. At the end of 2008 Rodríguez-Acosta reported 37 species, a number that after revision was up to 46 in October 2009. This increase in species number is because of the intensive exploration we have been doing since the beginning of this year. A good range of biological forms is found, from very tall trees such as *Q. corrugata* Hook. growing in different parts of Sierra Norte of Puebla, scrubby oaks such as *Q. sebifera* Trel. growing in Tehuacan Valley or ground cover shrubs such as *Q. repanda* Bonpl. Each one of these species has a particular beauty in the wild and they are adapted to different ecosystems.

We know now that the richest area for oak diversity in Puebla is the Sierra Norte, where the tallest oaks grow, and secondly the temperate forest in the volcanic transversal mountain range. The most restricted area for oaks is the south of Puebla which includes deciduous oaks of small size such as *Q. glaucoides* M. Martens & Galeotti, *Q. magnoliifolia* Née and *Q. liebmannii* Oerst. ex Trel. Two areas less explored are the coastal slope at the northeast and the Oaxaca mountain system between Puebla and Oaxaca.

We expect that these figures will change as our field work continues, but what they do show is that Puebla has a rich diversity that competes with the most oak-rich states of Mexico.

Actions to protect the oak forest

Human activity is the most important cause of forest destruction. In the forest there are enough seeds in most cases, and good seedling development. In the nursery, there is a good rate of germination, good growth, and seedlings establish well. However, we have observed that in order to grow a good oak in the field you need to take care of it during a period of five years and as financial resources for reforestation are scarce, replanting oaks in any number is difficult.

Our recommendation is to grow the oaks as close as possible to their final planting places and use the existing germplasm in the area as a seed source.

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Thanks to Charles Snyers d'Attenhoven for assistance with review.

The Oak Collection at the Botanic Garden in Puebla University

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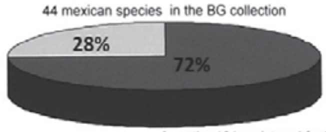
Mexico is one of the two diversification centres in the world for oaks with 160-200 species. The richest states in Mexico are Oaxaca, Jalisco, Nuevo León, Chihuahua, Puebla and Veracruz.

Since the foundation of the Botanic Garden, Quercus has been an important tree. here, *Quercus acutifolia* and *Q. glaucoides* were introduced in 1987.

The oak collection in the Botanic Garden in the University started in 1987 with the first specimens of Q. *acutifolia, Q. liebmannii, Q. castanea and Q. glaucoides*. Formal efforts to develop a *Quercus* collection started in 1995. Currently the collection has 61 especies, 15 from abroad that have been donated by several institutions and 44 Mexican species, 23 from section *Quercus*, white oaks (Table 1) and 21 from section *Lobatae* or red oaks (Table 2).

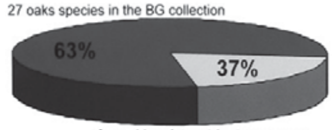
Percentage oak species representation at a national and state level

44 mexican species in the BG collection



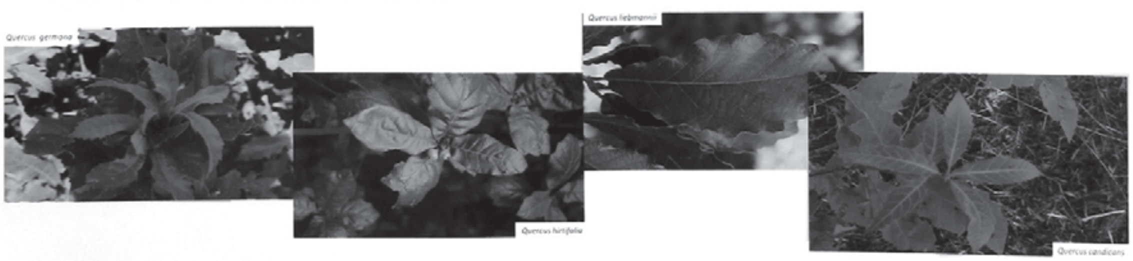
... from the 161 registered for Mexico

27 oaks species in the BG collection



from 44 registered for Puebla state

The species held in our collection correspond to 88% of the species reported for Morelos state, 86% of those reported in DF and Tlaxcala, 76% for Hidalgo, 71% for Veracruz, 62.5% for Oaxaca and 44 % from Guerrero.



Tabl2 1.- Section *Quercus* species or "white oaks" in the Botanic Garden-BUAP, And teir distribution in Mexico .

Specie	Distribution in Mexico per state
Quercus alpescens	Hgo, NL
Quercus corrugata	Chis, Gro, Oax, Pue, Ver
Quercus deserticola	DF, Gto, Hgo, Jal, Mex, Mich, Oax, Pue, Qro, Sin
Quercus fusiformis	Coah, NL, Tamps
Quercus germana	Hgo, Oax, Pue, SLP, Tamps, Ver
Quercus glabrescens	DF, Hgo, Méx, Mich, Oax, Pue, SLP, Tlax, Ver
Quercus glaucoides	Gro, Gto, Hgo, Jal, Méx, Mich, Mor, Nay, Oax, Pue, SLP, Sin, Zac
Quercus greggii	Coah, Dgo, Hgo, Nay, Oax, Pue, SLP, Tamps, Ver, NL
Quercus insignis	Oax, Ver
Quercus invaginata	Chih, Coah, NL
Quercus laceyi	Coah, NL
Quercus laeta	Ags, Coah, DF, Dgo, Gto, Hgo, Jal, Méx, Mich, Nay, NL, Pue, SLP, Sin, Oax, Zac
Quercus lancifolia	Chis, Ver, Pue
Quercus leiophylla	Hgo, Oax, Pue, Ver
Quercus liebmannii	Gro, Oax, Pue
Quercus microphylla	Ags, Coah, Gto, Hgo, Jal, Nay, NL, Oax, Pue, Qro, SLP, Tamps, Ver
Quercus obtusata	DF, Dgo, Gro, Gto, Hgo, Jal, Méx, Mich, Mor, Nay, Oax, Pue, Qro, SLP, Ver, Zac
Quercus oleoides	Cam, Chis, Hgo, Oax, Pue, SLP, Tab, Tamps, Ver, Yuc
Quercus polymorpha	Chis, Hgo, NL, Oax, Pue, SLP, Tamps, Ver
Quercus rugosa	Ags, Chis, Coah, Col, DF, Gro, Gto, Dgo, Hgo, Jal, Méx, Mich, Mor, NL, Oax, Pue, Qro, SLP, Son, Ver, Zac
Quercus sebifera	Chis, Hgo, NL, Oax, Pue, SLP, Tamps, Ver
Quercus subspathulata	Chih, Jal, Son, Gro
Quercus turbinella	BC, Chih, Son

Tabla 2.- Section Lobatae species or "red oaks" in the BG-BUAP and their distribution in Mexico.

Specie	Distribution in Mexico per state
Quercus acherdophylla	Hgo, Pue y Ver
Quercus acutifolia	Gro, Jal, Méx, Mich, Nay, Oax, Pue
Quercus affinis	Gto, Hgo, NL, Oax, Pue, Qro, SLP, Tamps, Ver
Quercus agrifolia	BC
Quercus canbyi	NL, Tamps
Quercus candicans	Chih, Chis, DF, Dgo, Gro, Hgo, Jal, Méx, Mich, Mor, Nay, Oax, Pue, Sin, Ver
Quercus castanea	Chis, Col, DF, Dgo, Gto, Gro, Hgo, Jal, Méx, Mich, Mor, Nay, Oax, Pue, Sin, SLP, Son, Ver
Quercus conzattii	Dgo, Jal, Nay, Oax, Zac
Quercus crassifolia	Chih, Chis, DF, Dgo, Coa, Gro, Hgo, Jal, Méx, Mich, Oax, Pue, Qro, SLP, Tlax, Ver, Zac
Quercus crassipes	Col, DF, Gto, Hgo, Jal, Méx, Mich, Mor, Oax, Pue, Qro, Tlax
Quercus depressa	Hgo, Oax, Pue y Ver
Quercus x dysophylla	DF, Gto, Hgo, Mex, Mich, Tlax y Ver
Quercus hirtifolia	Hgo y Pue
Quercus laurina	DF, Gro, Gto, Hgo, Jal, Mex, Mich, Mor, Oax, Pue, Qro, Tlax, Ver
Quercus mexicana	Coah, DF, Hgo, Mex, NL, Pue, Qro, SLP, Tams, Tlax y Ver
Quercus pinnativenulosa	NL, Qro, SLP, Tams y Ver, Hgo
Quercus rubramenta	Gro y Oax
Quercus rysophylla	Hgo, NL, Ver
Quercus sartorii	Hgo, Pue, Oax, Tams y Ver
Quercus skinneri	Chis, Oax
Quercus xalapensis	Hgo, SLP, Tamps, Ver

Mexican *Quercus* species in the Botanic Garden at Puebla University

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Quercus is a genus of trees and shrubs with between 300 and 600 species depending on current opinion.

Mexico is known as the primary center of diversity of the genus and according to Valencia (2004) there are 161 species in Mexico, all belonging to subgenus *Quercus*. 81 of these are in Section *Quercus*, 76 in Section *Lobatae* and 4 in Section *Protobalanus*. The Mexican states with the greatest species diversity are Oaxaca, Jalisco and Nuevo Leon. However, more than half of the states have records of at least 20 species, and the state of Puebla currently has more than 33 species registered.

The Botanic Garden of the Benemerita University of Puebla started in 1995 the development of an oak collection including some from other countries. After several trials, the collection has 170 individuals belonging to 61 species, of which 44 are Mexican. Of these, 23 belong to Section *Quercus* (Table 1), and 21 to Section *Lobatae* (Table 2). In addition there are two new species which are currently being described, one native to Oaxaca and Puebla and the other native to Hidalgo.

The oak species grown here include more than 80% of those reported for the states of Morelos, Federal District, Tlaxcala and Hidalgo. The collection is expanding but we need more introductions from states such as Guerrero, Nuevo Leon and Jalisco.

The species with the widest distribution are *Q. rugosa* Née, *Q. castanea* Née and *Q. crassifolia* Bonpl. while the more restricted (1 or 2 states) are *Q. alpescens* Trel., *Q. insignis* M. Martens & Galeotti, *Q. laceyi* Small, *Q. agrifolia* Née, *Q. canbyi* Trel., *Q. hirtifolia* M.L. Vázquez et al., *Q. rubramenta* Trel. and *Q. skinneri* Benth., without including the new species.

The oldest oaks in the collection are *Q. acutifolia* Née, *Q. liebmannii* Oerst. ex Trel., *Q. castanea* Née, *Q. germana* Schltdl. & Cham. and *Q. glaucoides* M. Martens & Galeotti which were introduced in 1987 when the botanic garden planting started. Some species such as *Q. berberidifolia* Liebm., *Q. pinnativenulosa* C.H. Mull., *Q. hirtifolia* M.L. Vázquez et al. and the 2 new species were collected in 2007 and 2008 and are waiting to be planted.

We have learned about growing oaks here through trial and error. In Puebla we have a lack of humidity, and cool and hot temperatures in the same day can kill the plants easily. These experiences have shown us that it is not easy to grow oaks in Puebla city and therefore it is necessary to avoid further reduction in the oak forests here. Torrential rains and use of forest leaf litter to be sold as pot compost promote soil compaction and impoverishment.

Quercus liebmannii in spring. photo©Maricela Rodríguez-Acosta

Quercus liebmannii
photo©Maricela Rodríguez-Acosta

We are now sure that our collection will grow steadily and every time we work in the field we find something interesting or a new location giving us more knowledge about oaks in Puebla. Undoubtedly, our garden is a good place to look at Mexican oaks.

Table 1. Oak species in Section *Quercus* in the Botanic Garden, showing the states where each species is reported in Mexico and the provenance of the collection.

Species	Distribution in Mexico	Provenance
Quercus alpescens	Hgo, NL	Hgo
Quercus corrugata	Chis, Gro, Oax, Pue, Ver	Ver
Quercus deserticola	DF, Gto, Hgo, Jal, Méx, Mich, Oax, Pue, Qro, Sin	Pue
Quercus fusiformis	Coah, NL, Tamps	NL
Quercus germana	Hgo, Oax, Pue, SLP, Tamps, Ver	Ver . Pue
Quercus glabrescens	DF, Hgo, Méx, Mich, Oax, Pue, SLP, Tlax, Ver	Pue
Quercus glaucoides	Gro, Gto, Hgo, Jal, Méx, Mich, Mor, Nay, Oax, Pue, SLP, Sin, Zac	Pue
Quercus greggii	Coah, Dgo, Hgo, Nay, Oax, Pue, SLP, Tamps, Ver, NL	NL
Quercus insignis	Oax, Ver	Ver
Quercus invaginata	Chih, Coah, NL	Coah
Quercus laceyi	Coah, NL	NL
Quercus laeta	Ags, Coah, DF, Dgo, Gto, Hgo, Jal, Méx, Mich, Nay, NL, Pue, SLP, Sin, Oax, Zac	Pue
Quercus lancifolia	Chis, Ver, Pue	Pue
Quercus leiophylla	Hgo, Oax, Pue, Ver	Ver
Quercus liebmannii	Gro, Oax, Pue	Pue
Quercus microphylla	Ags, Coah, Gto, Hgo, Jal, Nay, NL, Oax, Pue, Qro, SLP, Tamps, Ver	Pue
Quercus obtusata	DF, Dgo, Gro, Gto, Hgo, Jal, Méx, Mich, Mor, Nay, Oax, Pue, Qro, SLP, Ver, Zac	Gro, Pue
Quercus oleoides	Cam, Chis, Hgo, Oax, Pue, SLP, Tab, Tamps, Ver, Yuc	SLP
Quercus polymorpha	Chis, Hgo, NL, Oax, Pue, SLP, Tamps, Ver	NL
Quercus rugosa	Ags, Chis, Coah, Col, DF, Gro, Gto, Dgo, Hgo, Jal, Méx, Mich, Mor, NL, Oax, Pue, Qro, SLP, Son, Ver, Zac	Pue
Quercus sebifera	Chis, Hgo, NL, Oax, Pue, SLP, Tamps, Ver	Pue
Quercus subspathulata	Chih, Jal, Son, Gro	Gro
Quercus turbinella	BC, Chih, Son	?

Table 2.- *Quercus* species in Section *Lobatae* showing the states where they have been reported in Mexico and the provenance of the collection.

Species	State distribution in Mexico	Provenance
Quercus acherdophylla	Hgo, Pue, Ver	Pue
Quercus acutifolia	Gro, Jal, Méx, Mich, Nay, Oax, Pue	Pue
Quercus affinis	Gto, Hgo, NL, Oax, Pue, Qro, SLP, Tamps, Ver	Pue
Quercus agrifolia	BC	BC, USA
Quercus canbyi	NL, Tamps	NL
Quercus candicans	Chih, Chis, DF, Dgo, Gro, Hgo, Jal, Méx, Mich, Mor, Nay, Oax, Pue, Sin, Ver	Gro
Quercus castanea	Chis, Col, DF, Dgo, Gto, Gro, Hgo, Jal, Méx, Mich, Mor, Nay, Oax, Pue, Sin, SLP, Son, Ver	Pue
Quercus conzattii	Dgo, Jal, Nay, Oax, Zac	Oax
Quercus crassifolia	Chih, Chis, DF, Dgo, Gto, Gro, Hgo, Jal, Méx, Mich, Oax, Pue, Qro, SLP, Tlax, Ver, Zac	Pue
Quercus crassipes	Col, DF, Gto, Hgo, Jal, Méx, Mich, Mor, Oax, Pue, Qro, Tlax	Pue
Quercus depressa	Hgo, Oax, Pue, Ver	Hgo
Quercus hirtifolia	Hgo, Pue	Pue
Quercus laurina	DF, Gro, Gto, Hgo, Jal, Méx, Mich, Mor, Oax, Pue, Qro, Tlax, Ver	Pue
Quercus mexicana	Coah, DF, Hgo, Méx, NL, Pue, Qro, SLP, Tamps, Tlax, Ver	Pue
Quercus pinnativenulosa	NL, Qro, SLP, Tamps, Ver, Hgo	Hgo
Quercus rysophylla	Hgo, NL, Ver	NL
Quercus rubramenta	Gro, Oax	Gro
Quercus sartorii	Hgo, Pue, Oax, Tamps, Ver	Hgo, Ver
Quercus skinneri	Chis, Oax	Oax
Quercus ×dysophylla	DF, Gto, Hgo, Méx, Mich, Tlax, Ver	Pue
Quercus xalapensis	Hgo, SLP, Tamps, Ver	Ver

State abbreviations

Ags – Aguascalientes
BC – Baja California
Chih – Chihuahua
Chis – Chiapas
Coah – Coahuila
Col – Colima
DF – Distrito Federal
Dgo – Durango
Gro – Guerrero
Gto – Guanajuato
Hgo – Hidalgo
Jal – Jalisco
Méx – Estado de México
Mich – Michoacán
Mor – Morelos
Nay – Nayarit
NL – Nuevo León
Oax – Oaxaca
Pue – Puebla
Qro – Querétero
Sin – Sinaloa
SLP – San Luís Potosí
Son – Sonora
Tamps – Tamaulipas
Tlax – Tlaxcala
Ver – Veracruz
Zac – Zacatecas

Introducing a Collaborative Oak Collection from North America

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Guy Sternberg
Founder and Director, Starhill Forest Arboretum of Illinois College
Mindy Bumgarner, Arboretum Manager, Starhill Forest Arboretum

The public gardens of North America hold a well-documented and tremendously diverse representation of the world's plant life in their living collections. Unfortunately, more often than not, public gardens do not coordinate their plant collecting efforts. In 1995 the American Public Gardens Association (APGA, formerly AABGA) launched the North American Plant Collections Consortium (NAPCC) as a way to coordinate the conservation of plant diversity in North American gardens, recognize exceptional plant collections, and promote high standards of collection management.

For the first decade of the program, each recognized NAPCC collection was dedicated to a significant collection of a single plant group growing at a single garden. There are currently 31 plant genera or families that are represented in NAPCC collections by individual gardens. This model would not work well for oaks. The tremendous diversity of *Quercus* prevents any single garden from holding a comprehensive collection of the genus due to climatic limitations alone. In August of 2007 the first multi-institutional NAPCC collection was formed with the induction of 15 public gardens with large oak collections.

The growing NAPCC Multi-Institutional *Quercus* Collection now includes the following 16 member gardens, four of which sent representatives to the 6th International Oak Conference in Puebla to present information about their collections.

Chicago Botanic Garden, Glencoe, Illinois
Cornell Plantations, Ithaca, New York
Denver Botanic Gardens, Denver, Colorado
Holden Arboretum, Kirtland, Ohio
Landis Arboretum, Esperance, New York
Missouri Botanical Garden, Saint Louis, Missouri
Morris Arboretum of the University of Pennsylvania, Philadelphia, Pennsylvania
The Morton Arboretum, Lisle, Illinois
Mount Auburn Cemetery, Cambridge, Massachusetts

New York Botanical Garden, Bronx, New York
Rancho Santa Ana Botanic Garden, Claremont, California
Scott Arboretum of Swarthmore College, Swarthmore, Pennsylvania
Starhill Forest Arboretum, Petersburg, Illinois
The University of California Botanical Garden, Berkeley, California
UC Davis Arboretum, Davis, California
University of Washington Botanic Gardens, Seattle, Washington

These gardens are located in a diversity of climates across the United States and each makes a unique contribution to the overall collection. Curators and horticulturists from the member gardens collaborate on group goals and initiatives to improve the collection.

There are six goals for improving the NAPCC multi-institutional *Quercus* collection. Many of these reflect the overall goals of the entire North American Plant Collections Consortium program.

Goal 1: Promoting collaborations

Group collaboration is a fundamental underlying premise of a multi-institutional collection. The member gardens share plant inventories to allow tracking and analysis of the combined collection and facilitate the identification of gaps in the collection. From sharing advice and information to sharing acorns to collaborating on collecting expeditions, member gardens collaborate to help the collection grow.

Goal 2: Conserving germplasm

In order to join the NAPCC, each member garden needed to make an institutional commitment to maintain the genetic diversity of its oak collection. Like living libraries, the member gardens serve as public repositories of oak diversity, including wild species from around the world, natural and artificial hybrids, and cultivars.

Goal 3: Strategically expanding the collection

The NAPCC Multi-Insitutional *Quercus* Collection is by no means complete. Many oak species are still unrepresented in the group's combined holdings or are represented by just a few individuals. Group efforts to expand the collection are focused first on North American taxa followed by Asian and European species. Acquiring species of conservation concern is, of necessity, a higher priority. Many unrepresented North American oak species are from areas where there are currently no NAPCC gardens. Prioritizing the recruitment of new NAPCC gardens in the southeastern and southwestern United States as well as Mexico will be the most efficient method of increasing representation of taxa from these regions.

Goal 4: Elevating collection management standards

NAPCC member gardens are strongly encouraged to collect voucher herbarium specimens and photographic images as permanent scientific references for their collections. Many member gardens are sending duplicate vouchers to the US National Arboretum Herbarium and the Liberty Hyde Bailey Hortorium Herbarium at Cornell University for further study and verification at these institutions. The UC Davis Arboretum and Starhill Forest Arboretum have each recently embarked on oak collection photo documentation projects, and the group will be working on sharing photo protocols and plans for posting images online.

Goal 5: Supporting oak-related research

All the member gardens make their collections available for oak-related research, and keeping high standards of documentation ensures the scientific value of the collections. Having the combined oak collection inventory available online on the collection profile webpage (http://www.publicgardens.org/web/2008/08/multiinstitutional_quercus_oak.aspx) also improves researcher access to collection information.

Goal 6: Improving education and public awareness

A broad diversity of educational programs and events at the member gardens reach out to regional audiences and help connect them with the beauty and value of oaks. Journal articles and conference presentations for the American Public Gardens Association and the International Oak Society have spread news about the collection to international networks of oak specialists and public garden peers, and a webpage profiling the collection on the APGA website serves as an introduction and portal to the collection for web users worldwide.

Individual Collection Profiles

Profiles of four individual collection-holding gardens of the NAPCC *Quercus* Collection illustrate the unique qualities each garden brings to the group and how each contributes to group goals.

UC Davis Arboretum – Davis, California

Located on the campus of the University of California at Davis, the UC Davis Arboretum serves as a living museum of plants and a welcoming public outreach arm of the university. The Arboretum's documented plant collections are rich in California native plants and plants from the other Mediterranean climate regions of the world. Taxonomic, geographic, and horticultural collections serve as training grounds for interns, resources for university teaching and research, settings for tours and educational programs for visitors of all ages, and beautiful places for active recreation or peaceful contemplation.

A native population of California valley oaks (*Quercus lobata* Née) with some individuals up to 400 years old persists as a remnant of the original riparian forest along the Arboretum waterway. These massive trees with their ancient, twisted limbs are one of the Arboretum's greatest treasures. With a long growing season, a benign Mediterranean climate, and rich agricultural soils, the Arboretum is well-suited for growing a great variety of oaks. The Arboretum's NAPCC oak collection is our most important scientific collection, thanks in large part to the work of the late Dr. John M. Tucker, a former Arboretum director and lifelong oak scholar. The collection contains 578 oak specimens from 150 accessions, which represent 96 taxa.

The bulk of the UC Davis Arboretum's oak collection resides in Shields Oak Grove, a 10-acre grove at the west end of the Arboretum. Most of the trees

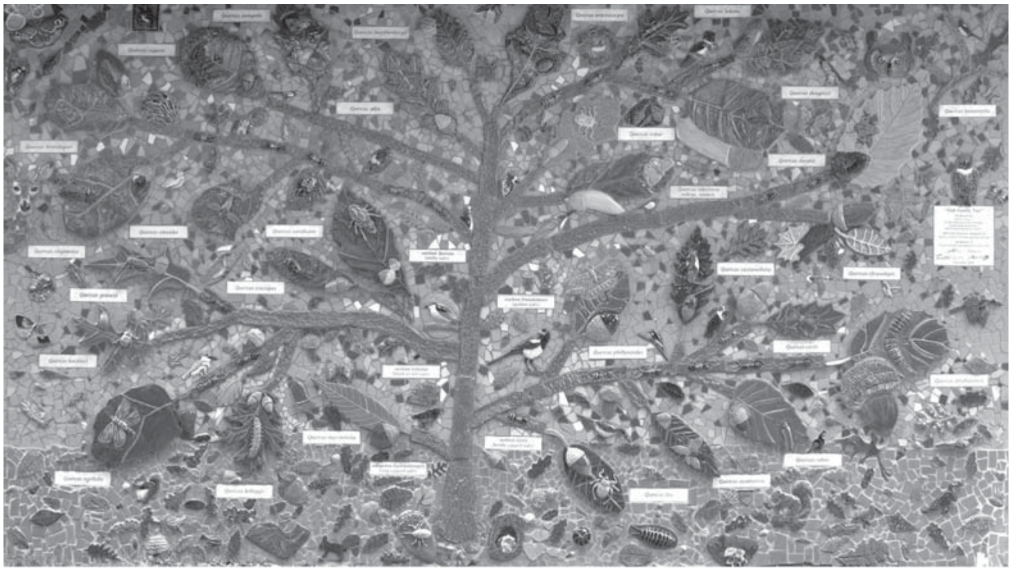

Fig. 1. The completed "Oak Family Tree" mural is a popular visitor attraction near the entrance to Shields Oak Grove. photo©Donna Billick

were planted from the early 1960s to the early 1970s, and many have grown into impressive mature specimens. Unique features of Shields Oak Grove include large collections of oaks from California, the Mediterranean region, Mexico, and Central America as well as an unusual series of experimental hybrid oaks created by Dr. Walter Cottam. The California island oak (*Quercus tomentella* Engelm.) from the California Channel Islands, the Oak of Tabor (*Quercus ithaburensis* Decne.) from Israel, and Brandegee oak (*Quercus brandegeei* Goldman) from Baja California, Mexico are three of the more unique oaks in the collection.

The Arboretum recently received funding from the Institute of Museum of Library Services to make Shields Oak Grove more physically and intellectually accessible to visitors with the development of an interpretive trail. The Oak Discovery Trail will not only be a physical pathway to guide visitors through the collection, it will also be a rich educational resource with plant labels, interpretive signs, and a cell phone audio tour. The trail development will be accompanied by extra training for volunteer tour guides on the oaks, so that they can share even more stories about the trees with visitors. However, the most innovative element of the Oak Discovery Trail project is the Arboretum's partnership with the UC Davis Art-Science Fusion program to develop permanent ceramic mosaic art features inspired by the oaks.

The Art/Science Fusion program, an undergraduate curriculum that links scientific learning with artistic expression, has a special affinity with Shields Oak Grove. The diverse oaks and the many animals and insects for which they provide habitats are a rich source for learning and creative inspiration. Diane Ullman, an entomology professor, and Donna Billick, a ceramicist and public artist, team up each fall to teach Entomology 1: Art, Science, and the World of Insects. In fall of 2008, the class project was to create a beautiful ceramic mosaic mural near the entrance of the Oak Discovery Trail. The name of the mural is "Oak Family

Tree," and it visually represents the evolutionary relationships among oak species in the Arboretum's living collection (Fig. 1).

Students in the course visited Shields Oak Grove at the beginning of the quarter to study oak taxonomy and diversity and to tour the collection. Each student worked with the ceramic artist instructor and Arboretum staff to create hand-built tiles accurately depicting a leaf, an acorn, and an associated insect for one of the oak species in the Arboretum's diverse collection (Fig. 2). Branches textured like oak bark connect the 29 oak species on the mural to reflect recent research on oak relationships. Many Arboretum volunteers, community members, and students from a local elementary school also participated in the creation of tiles for the mural.

The mural serves as a visitor-friendly and scientifically-appropriate introduction to the taxonomic collection in Shields Oak Grove, which has been used many times over the decades to study the evolutionary relationships of oaks. The Arboretum staff believes that this partnership with the Art/Science Fusion program can serve as a model for other gardens on involving community in the creation of art that illuminates the scientific meaning of plant collections for visitors.

Fig. 2. A UC Davis student shows off his *Quercus kelloggii* tile in Shields Oak Grove shortly before his mural installation.

photo©Allen Jones

Morton Arboretum – Lisle, Illinois

The Morton Arboretum's living collections represent one of the most comprehensive repositories of woody plant diversity in North America. Through the Arboretum's 87 years of history, plants have been acquired from various regions around the world. Presently the collections include 4,164 taxa of plants. Over 186,000 individual plants in the living collections are arranged according to five major themes: taxonomic, geographic, special habitat, horticultural, and rare and endangered.

Of them, the Oak Collection is one of the most significant collections at the Arboretum. It consists of well-documented oak species, cultivars, and hybrids. There are seventy-one different taxa and over 281 accessions of oaks that are represented by 1,069 individual plants from North America, Asia, and Europe. The collection is distributed across approximately 12 acres on the east side of the Arboretum.

The site was originally oak-dominated upland forest during pre-settlement times. During the 1800s, forest products were harvested and the cleared areas were farmed. As evidence of this original landscape, many mature white oaks (*Quercus alba* L.) and bur oaks (*Q. macrocarpa* Michx.) commonly occur in the Oak Collection and throughout the Arboretum (including the Illinois Millennium Landmark Tree, predating Illinois' 1818 statehood).

Native species are particularly well represented. Seventeen species out of the total twenty-one Illinois native species are growing in the collection. Among them, white oak is the dominant species. The white oak is the Illinois state tree, and a symbol of Midwestern history and the Midwestern landscape. Another important native oak species is the bur oak (*Q. macrocarpa*) that commonly occurs

The Morton Arboretum oak collection. photo©The Morton Arboretum

The Morton Arboretum. photo©The Morton Arboretum

throughout the region's prairies, savannahs and woodlands. Some new and interesting species added to the collection include a Turkey native, Hartwiss' oak (*Quercus hartwissiana* Steven); a Chinese native, Liaotung oak (*Quercus liaotungensis* Koidz.); and the Japanese native, gland bearing oak (*Quercus serrata* Murray).

The collection not only provides a great place to enjoy and study the diversity of oaks but also serves as an important resource for genetic conservation and scientific research. The collection provides the Arboretum with a great opportunity to conduct practical and scientific research in fields such as taxonomy, root biology, urban ecosystems, conservation, and woodland restoration.

photo©The Morton Arboretum

Morris Arboretum at the University of Pennsylvania – Philadelphia, Pennsylvania

The Morris Arboretum is a historic public garden and educational institution that promotes an understanding of the relationship between plants, people, and place through programs that integrate science, art, and the humanities. Among our many significant collections, the *Quercus* collection is a member of the NAPCC Multi-institution Oak Curatorial Group.

There are several aspects to this collection. The first are trees that are over 200 years old and were likely young plants when this area was first settled. Second, are trees that were planted when the property was the Morris Estate and that are

A veteran specimen of *Quercus ×benderi* growing at the Morris Arboretum.

photo©Paul W. Meyer

Winter scene of *Quercus bicolor* at the Morris Arboretum.

photo©Robert Gutowski

close to 100 years old. And finally, there are trees added over the past 75 years since we have become a public arboretum. In total we have 63 taxa of *Quercus* and 426 plants throughout the Arboretum.

With a large group of veteran and mature trees, we have started developing arboricultural techniques to preserve these plants for as long as possible, as long as they do not provide a hazard to the public or staff. In the past several years we have treated several of our oaks in ways that have helped sustain their growth, in particular by removing competition from turfgrass and by reducing the scale of the crown to encourage young interior growth. Treating these older plants as veteran trees is a relatively new concept in the United States and our goal is to develop long-range management plans for these specimens.

Our oak collection has been strengthened through domestic and international plant exploration, beginning in the 1950s with the Michaux Quercetum project and continuing for the past 30 years with plant exploration throughout Asia. Currently 62% of our trees are of wild-collected and documented origin, and the seed sources for our trees have come from six countries and 27 states of the U.S.

The uses of the *Quercus* collection at the Morris Arboretum support the goals of our mission, namely horticultural display, research, and education. These trees are planted throughout the Arboretum for the enjoyment of the general public. The trees have been used for breeding and propagation studies and for numerous classes that focus on plant care and identification. In summary, our oaks are a vital and integral part of all that we do as a public arboretum.

Starhill Forest Arboretum – Petersburg, Illinois

Founded in 1976 by Guy and Edie Sternberg, Starhill Forest was influenced strongly by many visits to the Morton Arboretum beginning in the 1950s. It is a small arboretum (48 acres / ~20 hectares) with approximately 150 accessioned genera of woody plants. *Quercus* has been the primary genus of focus almost from the beginning, and the current living collection of oaks comprises one of the most extensive in North America. More than 250 oak taxa are represented, largely from documented wild sources and including nearly 100 that are not fully hardy and must be maintained as container plants. Sand dune areas have been created in several locations and have been used successfully to establish many small oak species more than two USDA hardiness zones north of their normal limits in cultivation. These include *Q. chapmanii* Sarg., *Q. pumila* Walter, *Q. fusiformis* Small, *Q. rugosa* Née, *Q. gravesii* Sudw., *Q. turbinella* Greene, *Q. ×undulata* Torr., *Q. lusitanica* Lam., *Q. mohriana* Buckley ex Rydb., and others.

This is the most recent addition to the NAPCC Multi-Institutional *Quercus* Collection, having joined in 2009. Several new oak cultivars originated here, including *Q. texana* Buckley (syn. *Q. nuttallii* E.J. Palmer) 'New Madrid', *Q. ×warei* T.L. Green & W.J. Hess 'Windcandle', *Q. ×warei* × *Q. alba* 'Chimney Fire', *Q. ×warei* × *Q. alba* 'Birthday candle', *Q. alba* 'Brush Creek', *Q. alba* 'Gatton Grave', Q. alba 'Pathfinder', *Q. macrocarpa* 'Rough Rider', *Q. ×deamii* Trel. 'Champion Seedless', *Q. ×bebbiana* C.K. Schneid. 'Taco', and *Q. velutina* Lam. 'Oakridge Walker'. Several more selections are under observation for possible introduction.

Q. ×*sternbergii* photo©Guy Sternberg

Starhill Forest is the official arboretum of Illinois College, the oldest college in Illinois (Chartered in 1829). It remains under the direction of the Sternbergs, with internships, field labs, and credit study programs established for IC students. The collection also supports research for oak genetics, provenance testing, and general study, with more taxa available for observation in a small area than almost anywhere else in North America. Many International Oak Society members have visited here on their way to or from various IOS conferences since 1994, and seed exchanges with some of them have greatly enriched the arboretum. Seed obtained from the 2009 Mexico conference will continue to be shared with other NAPCC institutions and exchange partners.

An Open Invitation for Collaboration

There are many mutually beneficial opportunities for International Oak Society members to collaborate with the NAPCC Multi-Institutional *Quercus* Collection member gardens. Collection managers from the NAPCC member gardens have already been encouraged to join the International Oak Society and participate in IOS activities. Likewise, International Oak Society members are encouraged to help find and recruit new NAPCC gardens that will represent new geographic regions and expand the group's capacity to build the oak collection.

Potential joint projects for IOS members and NAPCC gardens include collecting expeditions, research projects, and acorn exchanges. Sharing information can also be useful to both parties for learning more about collecting localities, import regulations, propagation techniques, and more. IOS members are encouraged to take advantage of NAPCC oak collection resources. The NAPCC member gardens hold documented, diverse, and publicly accessible collections, often with mature specimens. They are reference sites for identification and potential sources of propagules (with permission). These gardens also serve as storehouses for information and expertise with specialized libraries, extensive horticultural records, and highly trained and dedicated staff.

Observation deck at Starhill Forest.
photo©Guy Sternberg

For those IOS members who live near a public garden with an NAPCC oak collection, please consider volunteering your oak expertise for the benefit of the garden. Specialized volunteer opportunities abound in the areas of collection care and maintenance, collection curation and documentation, and education and interpretation.

The International Oak Society and the NAPCC Multi-Institutional *Quercus* Collection are natural partners, and we hope that the two organizations can work together and benefit from each other's resources and expertise.

For more information:

Griswold, Emily. 2009. Conserving Oaks in North American Plant Collections: A Collaborative Approach. *International Oaks*, No. 20.

NAPCC webpage: http://www.publicgardens.org/web/2006/06/napcc_home.aspx

NAPCC Multi-Institutional Quercus Collection webpage: http://www.publicgardens.org/web/2008/08/multiinstitutional_quercus_oak.aspx

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Pond at Starhill Forest. photo©Guy Sternberg

Who am I this time?
The affinities and misbehaviors of Hill's oak.
(*Quercus ellipsoidalis* E. J. Hill).

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Introduction

Oaks, it has long been recognized, readily hybridize. They do not obey the limit to interspecific hybridization that is the hallmark of the biological species concept [1], and they have in fact been described by two of the leaders in the field of speciation as a "worst case scenario for the biological species concept" [2]. Pioneering work by James Hardin [3] showed hybridization among 14 of the 16 species recognized for eastern North America within the subgenus Quercus (white oaks), with hybridization occurring almost anywhere that white oaks grow in sympatry. In the molecular era, hybridization is often suggested by chloroplast sharing among species [4-6]. But in spite of this fact, nuclear markers in sufficient numbers can distinguish oak species [7-9], and the genetic groupings that result generally accord closely with our understanding of oak species limits based on morphology, geography, and ecology. The congruence among these data sources strongly suggests that oak species are genetically coherent across broad ranges.

In the North American Great Lakes region, the taxonomy of Hill's oak (*Quercus ellipsoidalis* E.J.Hill) and scarlet oak (*Q. coccinea* Münchh.) has long been recognized as problematic [8, 10-16]. The two species are largely allopatric but overlap in characters of the end buds, leaves, and acorns. In their purest expressions, there is no confusing them, but the overlap raises the question of whether the two are better treated as separate species [8, 17-19] or as endpoints on a morphological continuum [11, 12, 14, 15, 20, 21]. A second issue is the degree to which these species hybridize with black oak (*Quercus velutina* Lam.), which is widespread throughout the region occupied by both species and morphologically entangled with them [19].

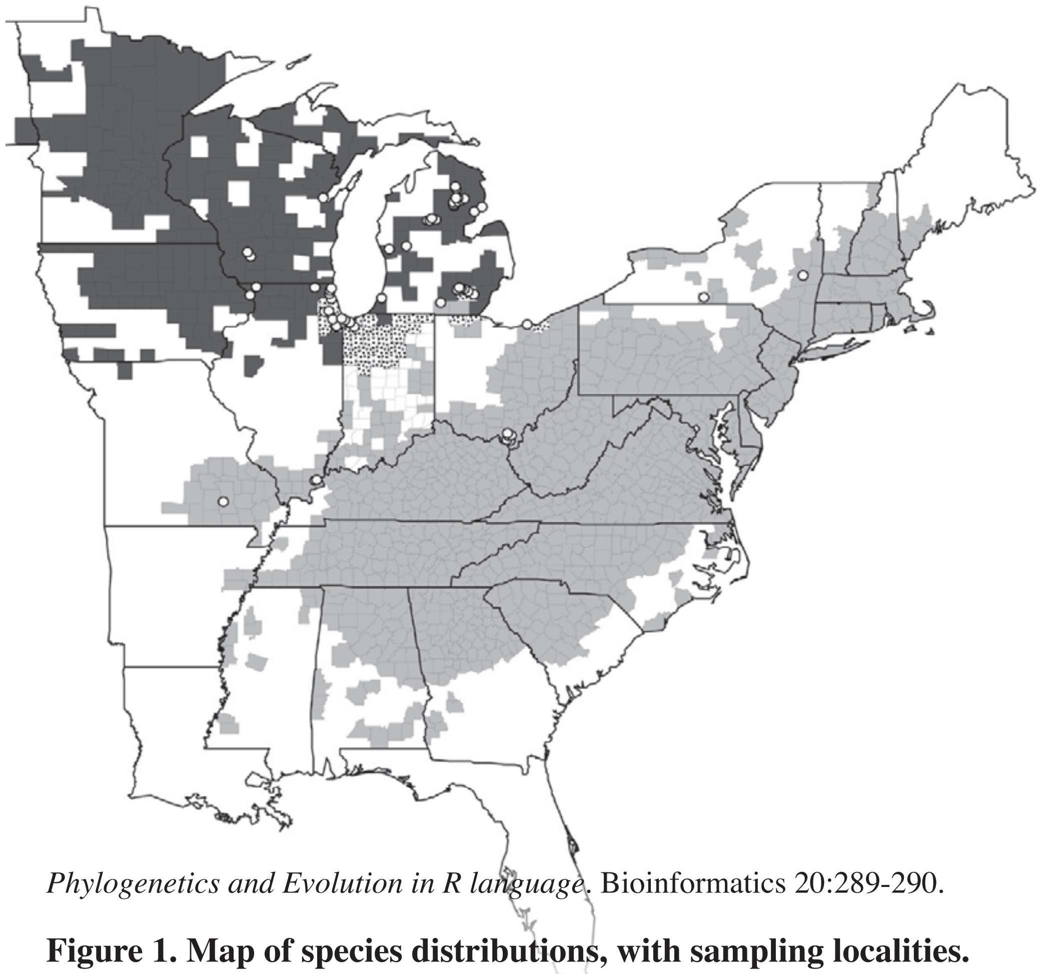
Previous molecular genetics work on these species demonstrated that scarlet oak is distinct from both Hill's oak and black oak, that black oak and Hill's oak are genetically similar to one another and may hybridize, and that genetic intermediacy between black oak and Hill's oak correlates poorly with morphological intermediacy [8]. In demonstrating that Hill's oak and black oak grade into each other morphologically and genetically in the Great Lakes region, while Hill's oak and scarlet oak grade into each other morphologically but apparently not genetically, the study raised the intertwined issues of the evolutionary origins of Hill's oak and relatives and their ongoing gene flow. Is

Hill's oak derived from within black oak, its similarity to scarlet oak an expression of shared ancestral characters that have been lost in black oak? Alternatively, is Hill's oak more closely related to scarlet oak, and genetically similar to black oak due to interspecific gene flow? The alternative effects of gene flow and phylogeny in explaining genetic similarity can be difficult to tease apart [22, 23], and in this study we utilize a combination of population-genetic, phylogenetic, and biogeographic approaches to try to do so.

Our current work is focused on three primary questions. First, we are interested in the phylogeny (evolutionary relationships) of the black oak species of eastern North America, particularly in order to know whether Hill's oak and scarlet oak are in fact sister species. Second, we are interested in deepening our understanding of the genetic disjunction between Hill's oak and scarlet oak by sampling populations of the former from northwest Indiana and southern Michigan, where the two species have been thought to be sympatric, and of the latter from northeastern North America, where the morphology is quite different from the forms observed in southern Missouri, Illinois, and Ohio. Finally, we are interested in evaluating the patterns of gene flow within Hill's oak and black oak and among populations of the two species, to understand whether the limited genetic structure that we found within each species in our previous work holds up with additional sampling and whether there is local gene flow between the species.

Methods

Our study is based on a genotyped sample of 803 individuals from six species—black oak, Hill's oak, scarlet oak, pin oak (*Quercus palustris* Münchh.), red oak (*Q. rubra* L.), and Shumard's oak (*Q. shumardii* Buckley)—collected from 58 sites, including 803 individuals from the three focal species and 24 from red oak (Figure 1). Individuals were assigned to populations based on their identification and site; thus, individuals of black oak from a given site were considered one population, while individuals of Hill's oak or scarlet oak from that same site were considered a second population. Sites were defined by groups of individuals found within an area of 4 km in radius about a common central point, which was geolocated using a GPS (global positioning system) unit. Genotypes were characterized using amplified fragment length polymorphism (AFLP) data [24] using methods described in [8]. Genetic disjunctions were identified both at the individual level and at the population level. Gene flow among and within species was assessed only at the population level. Although our morphological determinations largely correspond with the genetic clusters identified in this study, in several cases there is a mismatch between genetic and morphological identifications of individuals. Consequently, population-based analyses were conducted on three sets of individuals: all individuals identified based on morphology and reliably assigned to one species; all individuals identified based on genetic clustering with ≥ 65% assignment to a single species based on Bayesian clustering; and all individuals that had morphological and genetic identifications the same and ≥ 65% assignment to a single species based on Bayesian clustering. This last grouping, referred to hereafter in the paper as the ID-consensus group,



Phylogenetics and Evolution in R language. Bioinformatics 20:289-290.

Figure 1. Map of species distributions, with sampling localities.

The distribution of Hill's oak (*Quercus ellipsoidalis*) is mapped in dark grey, the distribution of scarlet oak (*Q. coccinea*) in light grey. Speckling indicates counties in which both species have been reported. Dots indicate sites where species were sampled for the current study. Note that only pin oak (*Q. palustris*) was sampled from the northern Ohio locality. Base map adapted from [8], with Indiana distribution according to [26].

is the most stringent and is the only one reported in most of this paper. Results of analyses using the other groupings had no effect on the conclusions of this study.

Results and Discussion

Phylogeny. Our first major finding is that with broadened sampling and additional data, we find that Hill's oak and scarlet oak are sister species and genetically coherent (Figure 2). The sister species relationship between Hill's oak and scarlet oak is borne out with additional sampling of 10 AFLP loci and well supported (bootstrap support = 0.85; data not shown). This is a satisfying result, given the long-standing taxonomic uncertainty regarding Hill's oak and scarlet oak. It also answers a question raised in our previous work about the degree to which the genetic similarity of Hill's oak and black oak might be due to recent divergence versus introgression ([8], p. 155). As Hill's oak and scarlet oak are

Figure 2. Relationships among populations of Hill's oak (*Quercus ellipsoidalis*) and allies.

Genetic distances among all populations were estimated using Nei's genetic distance, with distances corrected for dominant markers using the method of Lynch and Milligan [27] as implemented in AFLP-SURV [28]. The resulting pair wise genetic distance matrix was used to estimate genetic relationships among populations using the unweighted minimum evolution algorithm of Desper and Gascuel [29] as implemented in ape [30]. For sake of reconstructing relationships among populations, individuals included in analysis were limited to the ID-consensus group with population assignment ≥ 80% to one species. Sensitivity of the topology and population distinctions will be investigated in subsequent work.

sister species, their morphological similarity is most parsimoniously explained as a consequence of shared derived characteristics. The genetic similarity between Hill's oak and black oak is likely due to ongoing gene flow between the two.

One aspect of our finding is especially interesting in light of recent work by Dave Shepard [15] that demonstrates the morphological similarity between populations of scarlet oak in northeastern North America and Hill's oak of the Great Lakes region. We now find from the standpoint of molecular genetics that the New York populations of scarlet oak that we sampled are genetically more similar to Hill's oak than any of the other scarlet oak populations we sampled (Figure 2). The genetic disjunction between the species still appears to be broad, as our previous work suggested. Whether morphologically intermediate populations of Hill's oak and scarlet oak are consistently genetically intermediate requires additional study.

Species distinctions and hybridization. Our second major finding is that when we analyze individuals rather than populations, the species separate out cleanly (data not shown), though with some remarkable misclassifications between black oak and Hill's oak, i.e., incongruence between our identifications based on morphology and the population assignments based on genetic data (e.g., 14 *Q. velutina* out of 286 sampled with > 0.20 assignment to *Q. ellipsoidalis*). This mismatch between genetic and morphological species assignments is a hallmark of introgressive hybridization and has been reported previously in oaks [25], and the presence of such individuals supports the hypothesis of gene flow between the two species. Gene flow between the two species is also supported by preliminary study of pubescence on the inner surface of the acorn cap, which appears to correlate with genetic admixture estimates (Figure 3, next page).

This work is preliminary, and we are investigating further to determine whether the correlations will hold up with additional sampling. There is also some evidence of allele-sharing between Hill's oak and scarlet oak (3 *Q. coccinea* out of 101 sampled with > 0.20 assignment to *Q. ellipsoidalis*; 16 *Q. ellipsoidalis* out of 370 sampled with > 0.20 assignment to *Q. coccinea*). However, the presumably recent divergence between these two species begs the question of whether this apparent allele sharing is a consequence of shared ancestral polymorphism or ongoing gene flow in spite of allopatry.

Related to the hypothesis of introgressive gene flow between Hill's oak and black oak, we find some evidence for allele sharing between local populations of the two species in the upper Great Lakes region, where the two occur in sympatry. This finding is based on our finding of a positive correlation between geographic distance and genetic distance in pairwise comparisons between black oak and Hill's oak populations ($r = 0.1087$, 2-tailed $P = 0.073$ based on 2000 permutations). The significance of this correlation is not strong, and while the correlation is still positive even when only individuals with ≥ 95% assignment to one species are included in analysis ($r = 0.1316$, 2-tailed $P = 0.216$ based on 2000 permutations; note that the stronger correlation but weaker significance may be a consequence of the reduced sample size in the second test), the finding bears further study. However, if borne out, localized gene flow between the species would accord with previous morphological work by Jensen [19] suggesting that hybridization between Hill's oak and black oak may be relatively common.

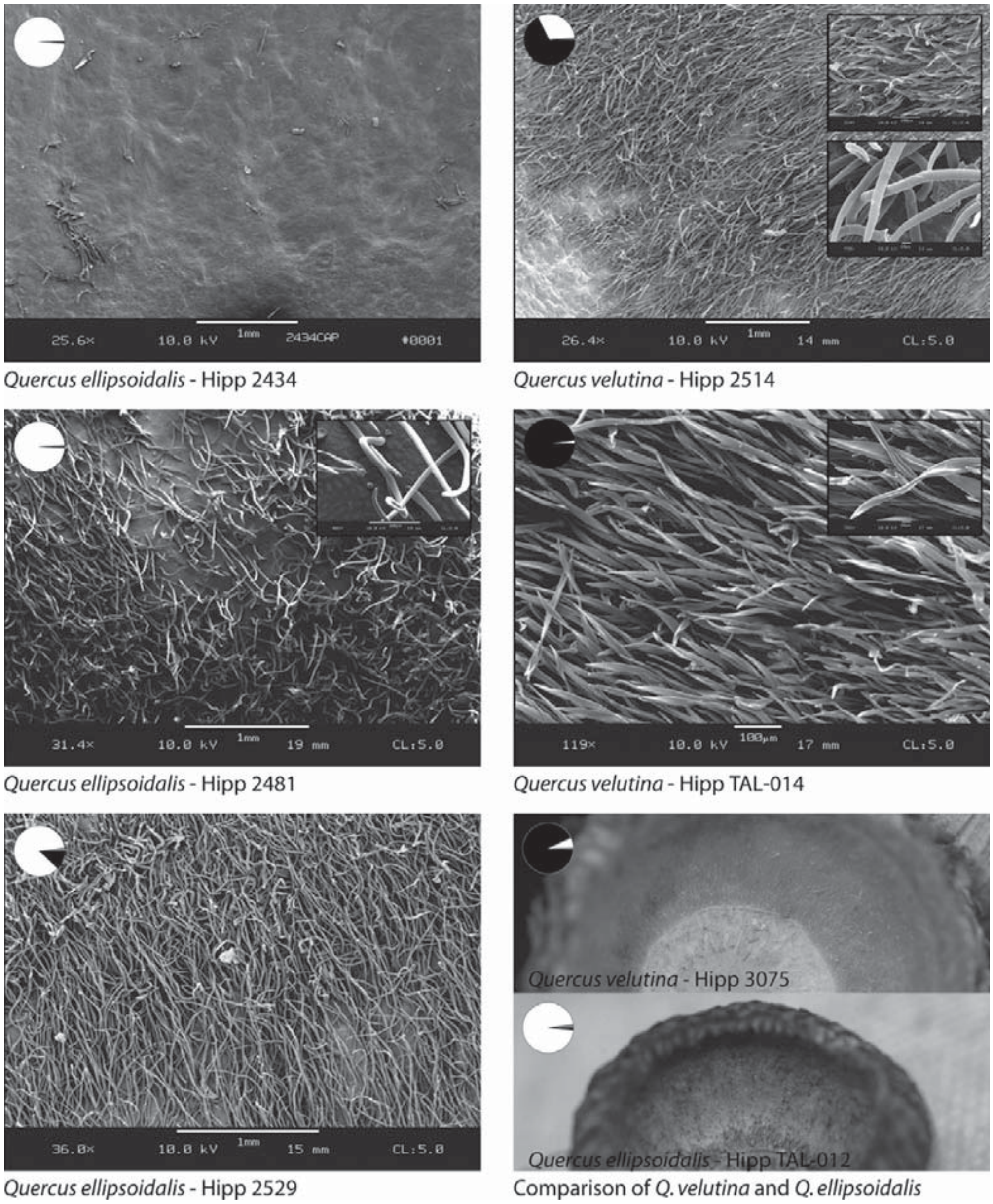


Figure 3. Pubescence on the inner surface of the acorn cap in Hill's oak (*Quercus ellipsoidalis*) and black oak (*Q. velutina*).

Images show scanning electron microscope images (A–E) or binocular light microscope images (F, G) of the inner surface of the acorn cap in Hill's oak (A–C, F) and black oak (D, E, G). Pie charts in the upper left-hand corner of each panel indicate the percentage of each individual's genome estimated to have derived from each of four ancestral populations: scarlet oak, *Q. coccinea* (red); Hill's oak (white), red oak, *Q. rubra* (yellow); and black oak (black). The figure demonstrates that pubescence on the inner surface of the acorn cap in the Hill's oak individuals sampled ranges from absent (A, G) to moderate (panel B); in the latter case, trichomes are slender and approximately cylindrical, often

(caption information continued on next page)

curling. In most of the black oaks we have sampled, pubescence is dense (E, F), the trichomes flattened and more or less appressed. In individuals that are genetically intermediate moderate pubescence may be found (C, D), along with both trichome types (D). This illustration represents a preliminary investigation of the relationship between genetic admixture and pubescence on the inner surface of the acorn cap, and bears further study. In particular, ongoing work in northern Michigan suggests that the pubescence type typical of black oak may be found in some individuals that are admixed or genotype as Hill's oak.

Genetic variance among populations within Hill's oak. Our third major finding is that there is significant population genetic structure in Hill's oak, and that genetic structure has a geographic component. Our previous work suggested that a four-population model fits our three-species dataset significantly better than a three-population model, and that the fourth population which we inferred captured geographic variation primarily within Hill's oak ([8], p. 152 and Figure 7B). In the current study, we similarly find that a seven-population model best fits our four-species dataset (comprising red, black, Hill's, and scarlet oak), and that four of the seven inferred populations are predominantly found within our concept of Hill's oak (data not shown). The population genetic structure suggests a geographic differentiation within Hill's oak, with many populations in Michigan and northwestern Indiana separating from Wisconsin and northeastern Illinois. This geographic structure has moderate statistical support based on correlations of geographic distances and genetic distances between populations ($r = 0.0916$, 1-tailed $P = 0.0535$ based on 2,000 Mantel permutations). This geographic genetic structure is particularly remarkable given that the maximum geographic distance between the Hill's oak populations that we sampled is just over 550 km, whereas the geographic distance between the most distant black oak populations sampled is over 1100 km. No geographic signal was detected in black oak ($r = 0.0783$, 1-tailed $P = 0.2409$ based on 2,000 Mantel permutations).

Conclusions

The work reported in this paper contributes to our understanding of the taxonomy and evolution of Hill's oak, black oak, and scarlet oak in three ways. First, it demonstrates that Hill's oak and scarlet oak are sister species (Figure 2), which suggests that their morphological similarity is a consequence of shared ancestry, not convergence or gene flow. Variance in the morphology of both species, such that they overlap morphologically, may be reflected in their population genetic structure. Strong genetic disjunction between the two is consistent with recognition at the species level. Second, it demonstrates that there is substantial geographically-structured genetic variation within Hill's oak that is not present in the other two species. This may reflect the biogeography of Hill's oak, which is essentially wrapped around Lake Michigan (Figure 1); differential rates or patterns of gene flow among Hill's oak, black oak, and red oak in different regions; or a higher rate of population differentiation within Hill's oak for other causes. Finally, the paper provides strong evidence for introgression between Hill's oak and black oak based on morphological data, and preliminary morphological and molecular evidence for ongoing local gene flow between the species. However, evidence for the latter is preliminary and bears further study.

Acknowledgements

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New Oak Cultivars from Belgium and France

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The *International Oak Society* was appointed by the International Society for Horticultural Science (ISHS) as International Cultivar Registration Authority (ICRA) for the genus *Quercus* in 1998. The system of ICRAs aims to promote stability in the naming of cultivated plants by publishing lists of authenticated names in a number of important groups of plants which are commonly cultivated (Trehane, 2007).

A selection which is represented by a single plant in a collection or nursery is not a cultivar; it is just a single specimen. A cultivar is a taxonomic unit made up of a number of plants with the same set of characters. Therefore, a single selected plant needs to be (vegetatively) propagated to obtain a certain number of identical plants. The number of new oak cultivars selected or raised by nurserymen or originating in botanical collections has risen rapidly over the last few years. The ICRA registers cultivar or Group names, describes the new cultivar and maintains records of the origin, characteristics, and history, without judgment of the value or distinctness of the cultivar. This is up to the breeder or finder of the cultivar.

The description of a new cultivar follows the International Code of Nomenclature for Cultivated Plants (ICNCP) (Trehane, 1995). Despite a description of new cultivars, the act of establishment under the ICNCP is to fix new cultivar names. Commonly spoken, a new cultivar does not "exist" until it receives an established name.

A searchable database of registered names and Groups and guidelines for oak cultivar registration can be found at *www.oaknames.org* or from the International Oak Society homepage at *www.internationaloaksociety.org*

The new cultivars described and new oak cultivar names published here are accompanied by herbarium specimens, which are deposited as Standard Specimens in the Harold Hillier Herbarium (HILL) at the Sir Harold Hillier Gardens, the official herbarium of the International Oak Society. The holdings of that herbarium, as well as the living collections, can be consulted online using the search facility from the Garden's homepage at *www.hilliergardens.org*.uk.

Belgium

In Belgium, the well known dendrologist André Charlier, of Arboretum Rond Chêne in Esneux, selected during the last decade several oaks mainly from seedlings that were wild collected by him in eastern Europe. Some of his selections are already in the nursery trade in Belgium and The Netherlands, and thus need descriptions as new cultivars.

Quercus **'Arthenice'** (Figure 1a). New cultivar and new cultivar name. Deciduous tree. Leaves up to 10.5 x 4.5 cm, edged with 8-9, acute, slightly

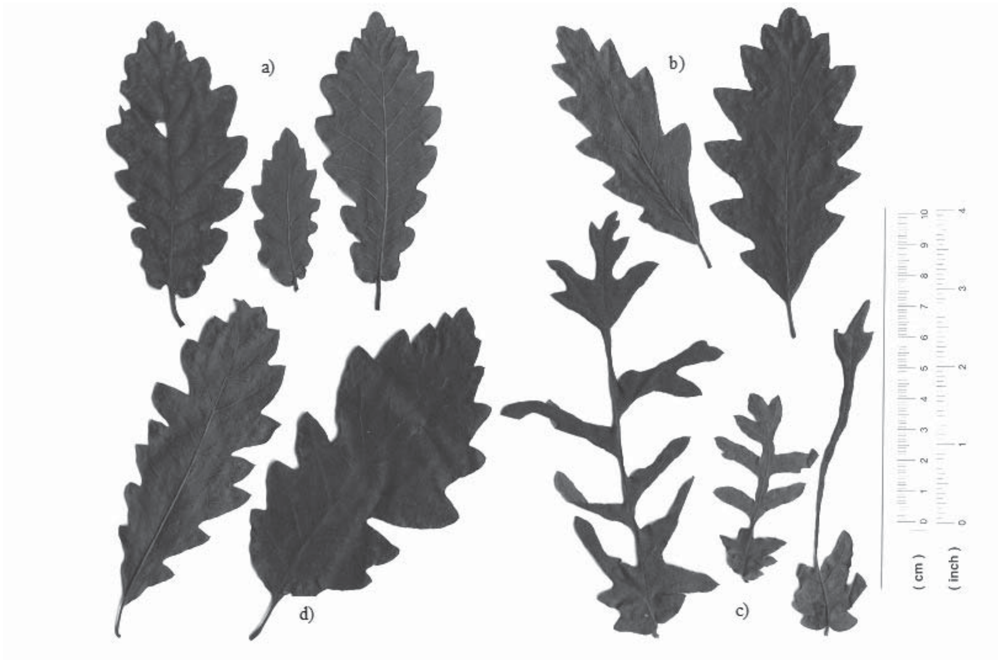

Fig. 1: **a)** *Quercus* 'Arthenice'; **b)** *Quercus cerris* 'Arnissa'; **c)** *Quercus cerris* 'Mercedes' **d)** *Quercus cerris* 'Slivno-Ravno'**.**

undulate lobes on each side, glossy dark green above and paler beneath, base cordate, often asymmetrical with a distinct red to brown-red petiole, 3-12 mm. The pointed acorns are up to 4 cm long and show, when ripe, a certain rusty color (not as brown as *Quercus robur* L.). Originated in 1987 from seed collected in the public park "Pincio" in Rome, Italy, under an oak showing a unique upright growth. The 29 year old plant has reached 9 x 4 m. It is possibly a hybrid of *Quercus canariensis* Willd. × *Quercus robur* × *Quercus petraea* (Matt.) Liebl. Standard Specimen: Harold Hillier Herbarium (HILL), Standard Specimen No. 6812, E.J.Jablonski 08082009, 20 August 2008, collected together with Piers Trehane and André Charlier. Named by André Charlier after his daughter Catherine, of which Arthenice is an anagram. From the original plant, at Arboretum Rond Chêne, Esneux, Belgium.

Quercus cerris L. **'Arnissa'** (Figure 1b). New cultivar and new cultivar name. A form selected for its chestnut like large leaves and vigorous growth. Leaves up to 16 x 8 cm, with 4-7 acute lobes on each side, base symmetrical attenuate, petiole 8-18 mm. Originated 1978 from seed collected in Arnissa, Northern Greece. The 30 year old plant has reached 15 x 5 m. Standard Specimen: Harold Hillier Herbarium (HILL), Standard Specimen No. 6804, E.J.Jablonski 08082007, 20 August 2008, collected together with Piers Trehane and André Charlier. Named by André Charlier after the village of Arnissa, which is situated along the shore of the Vegoriti-Lake in Kentriki Makedonia, Greece, at an elevation of 870 meters. From the original plant, at Arboretum Rond Chêne, Esneux, Belgium.

Quercus cerris L. **'Mercedes'** (Figure 1c). New cultivar and new cultivar name. A form selected for its deeply dissected leaves up to 14.5 x 7.5 cm, which are dull-green above, pale grey beneath and densely stellate-hairy on both sides, base asymmetrical, auriculate, petiole very short, 1-4 mm. The dissection sometimes reaches to the midrib, with up to 2 cm space between the lobes. Originated around 1990, raised from seed collected in Central Turkey. The 18 year old plant has reached 4.5 x 3 m, showing a loosely upright growth. Standard Specimen: Harold Hillier Herbarium (HILL), Standard Specimen No. 6805, E.J.Jablonski 08082003, 20 August 2008, collected together with Piers Trehane and André Charlier. Named by André Charlier after his wife Mercedes. Figure 2 shows André Charlier with the original plant of *Quercus cerris* 'Mercedes'. From the original plant, at Arboretum Rond Chêne, Esneux, Belgium.

Fig. 2: André Charlier with original *Quercus cerris* 'Mercedes'.

Quercus cerris L. **'Slivno-Ravno'** (Figure 1d). New cultivar and new cultivar name. A form selected for its very large, dark green leaves. Leaves up to 17 x 9.5 cm, green and rough above, paler beneath, with few stellate hairs on both sides, base asymmetrical, shortly attenuate, petiole 7-20 mm. Originated around 1972 raised from seed collected at Slivno-Ravno war memorial, on the shore of the Mediterranean Sea, where the road to Sarajevo goes inland, in Croatia. The 36 year old tree has reached 12 x 6 m, with a good central leader. Standard Specimen: Harold Hillier Herbarium (HILL), Standard Specimen No. 6806, E.J.Jablonski 08082005, 20 August 2008, collected together with Piers Trehane and André Charlier. Named by Charlier. From the original plant, at Arboretum Rond Chêne, Esneux, Belgium.

Quercus cerris L. **'Sveti Nahoum'** (Figure 3a). New cultivar and new cultivar name. A form selected for its large, green leaves and fast growth. Leaves

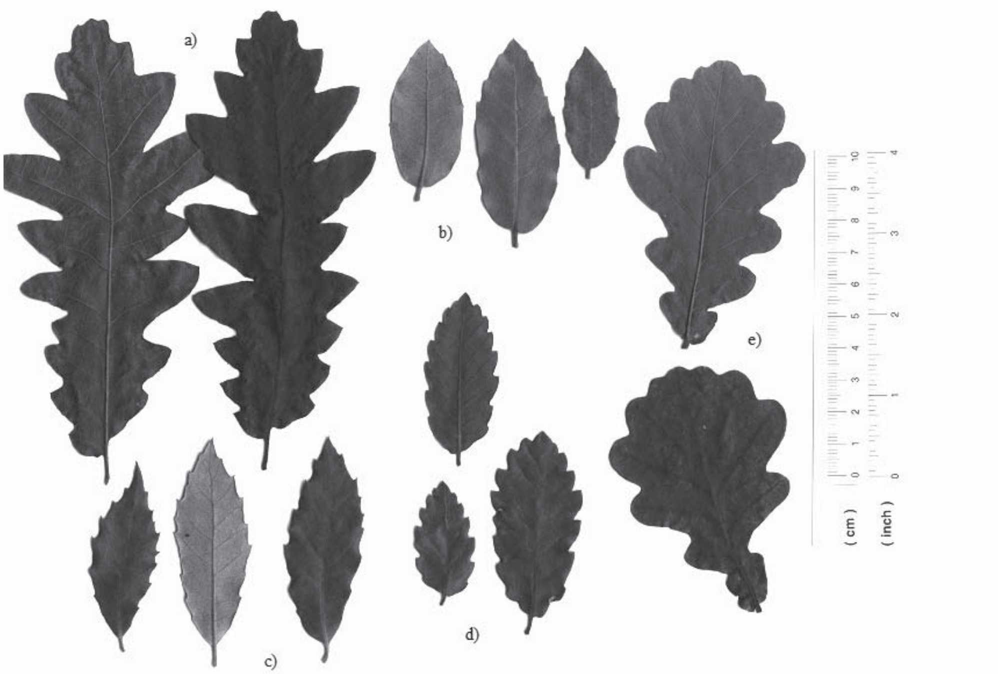

Fig. 3: **a)** *Quercus cerris* 'Sveti Nahoum'; **b)** *Quercus ilex* 'Despina'; **c)** *Quercus ilex* 'Verduzzo'; **d)** *Quercus* 'Sebrena'; **e)** *Quercus robur* 'Montefiore'.

up to 14.5 x 7 cm, green and rough above, paler beneath, with few stellate hairs on both sides, base asymmetrical shortly attenuate to subcordate, petiole 5-17 mm. Originated 1972 from seed collected at Sveti Nahoum, Macedonia. The 36 year old plant has reached 14 x 4 m of quite narrow growth, which may be a result of the narrow space at the growing site. Standard Specimen: Harold Hillier Herbarium (HILL), Standard Specimen No. 6807, E.J.Jablonski 08082006, 20 August 2008, collected together with Piers Trehane and André Charlier. Named by André Charlier after the orthodox monastery Sveti Nahoum, near the lake and city of Ochrid in Macedonia, former Republic of Yugoslavia. From the original plant, at Arboretum Rond Chêne, Esneux, Belgium.

Quercus ilex **L. 'Despina'** (Figure 3b). New cultivar and new cultivar name. Selected for its slow and narrow growth. An evergreen tree. Young shoots densely grey-hairy, as are the undersides of the leaves. Leaves lanceolate, up to 8 x 3 cm; dark green above and sparsely hairy; petiole 0.7-1 cm with a few spines in the upper half of the leave blade, margin more or less undulate. Leaf apex apiculate. Originated around 1990, raised from seed of *Quercus ilex* 'Fordii' growing at Arboretum Rond Chêne, Esneux. The 18 year old plant has reached only 3 x 1 m. Standard Specimen: Harold Hillier Herbarium (HILL), Standard Specimen No. 6808, E.J.Jablonski 08082002, 20 August 2008, collected together with Piers Trehane and André Charlier. Named by Charlier after the character "Despina" from Mozart's opera "Cosi fan tutte" (in Greek mythology, the nymph "Despina" is the daughter of Poseidon). From the original plant, at Arboretum Rond Chêne, Esneux, Belgium.

Quercus ilex **L. 'Verduzzo'** (Figure 3c). New cultivar and new cultivar name. An evergreen tree that originated around 1974, young shoots grey-green hairy, as are the undersides of the leaves. Leaves lanceolate, up to 5.5 x 2.8 cm; fresh green above and sparsely hairy; petiole 0.7-1 cm, margin more or less undulate with a few spines on the terminal half of the leaf blade. Leaf apex apiculate. The whole tree has a fresh green look. Raised from seed collected on the Dalmatian coast opposite the island of Rab in Croatia. Out of a batch of some 100 acorns, only this one germinated. The 20 year old plant has reached 7 x 4 m. Standard Specimen: Harold Hillier Herbarium (HILL), Standard Specimen No. 6810, E.J.Jablonski 08082008, 20 August 2008, collected together with Piers Trehane and André Charlier. Named by Charlier after the fresh green wine called «Verduzzo» from Friaul province, Italy. From the original plant, at Arboretum Closerie Chêne, Esneux, Belgium.

Quercus robur L. **(Fastigiata Group) 'Montefiore'** (Figure 3d). New cultivar and new cultivar name. A form selected for narrow fastigiate growth. Leaves up to 9.5 x 5.7 cm, base cordate, petiole 1-4 mm. Fruits like typical *Quercus robur*. The original plant is a chance seedling on the grounds of the neighboring "Château du Rond Chêne" at Esneux, Belgium, reaching after some 50 years 20 x 2 m. Standard Specimen: Harold Hillier Herbarium (HILL), Standard Specimen No. 6811, E.J.Jablonski 08082004, 20 August 2008, collected together with Piers Trehane and André Charlier. Named by André Charlier after the old owner of the castle Rond Chêne, Monsieur Montefiore. From the original plant, at Arboretum Château du Rond Chêne, Esneux, Belgium. Figure 4 shows the first graft made from the original tree, a 10 year old *Quercus robur* 'Montefiore' with André Charlier (left) and Piers Trehane (IOS oak registrar, right).

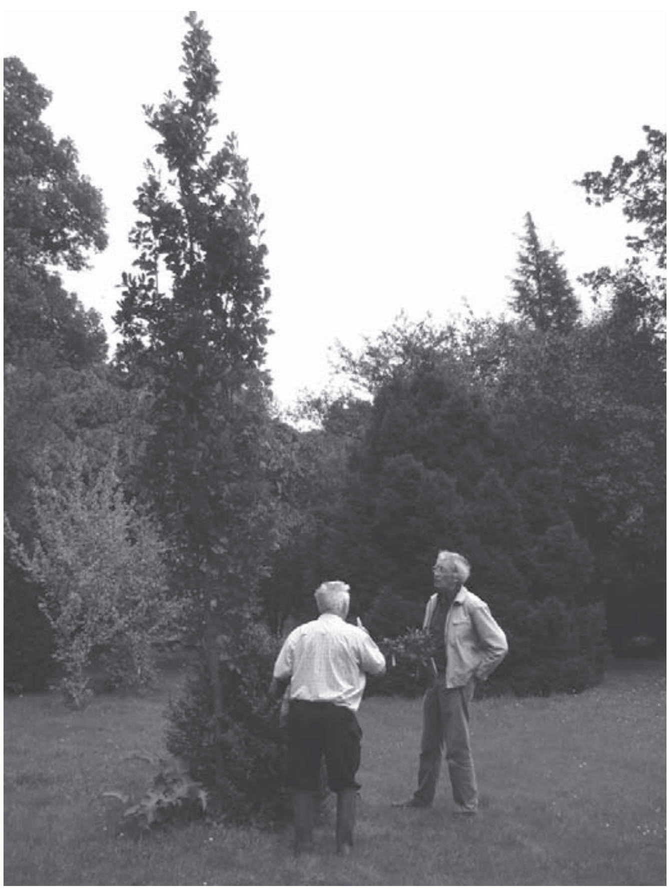

Fig. 4: André Charlier (left) and Piers Trehane (IOS ICRA oak registrar) with a graft of *Quercus robur* 'Montefiore'.

***Quercus* 'Sebrena'** (Figure 3e). New cultivar and new cultivar name. A form selected for its beautiful leaves and slow and upright growth, a seedling of Qu*ercus ilex* 'Fordii' and most possibly a hybrid with *Quercus pubescens* Willd. (= *Quercus* × *albescens* Rouy ex Camus)**.** Leaves up to 7 x 3 cm, semi-deciduous, dark-green above, paler below, with very few stellate hairs above and densely hairy beneath, slightly undulate margin, base cuneate-subcordate, petiole 3-6 mm. Originated around 1972, raised from seed of *Quercus ilex* 'Fordii' growing at Arboretum Rond Chêne, Esneux. Out of the batch of seedlings this one was

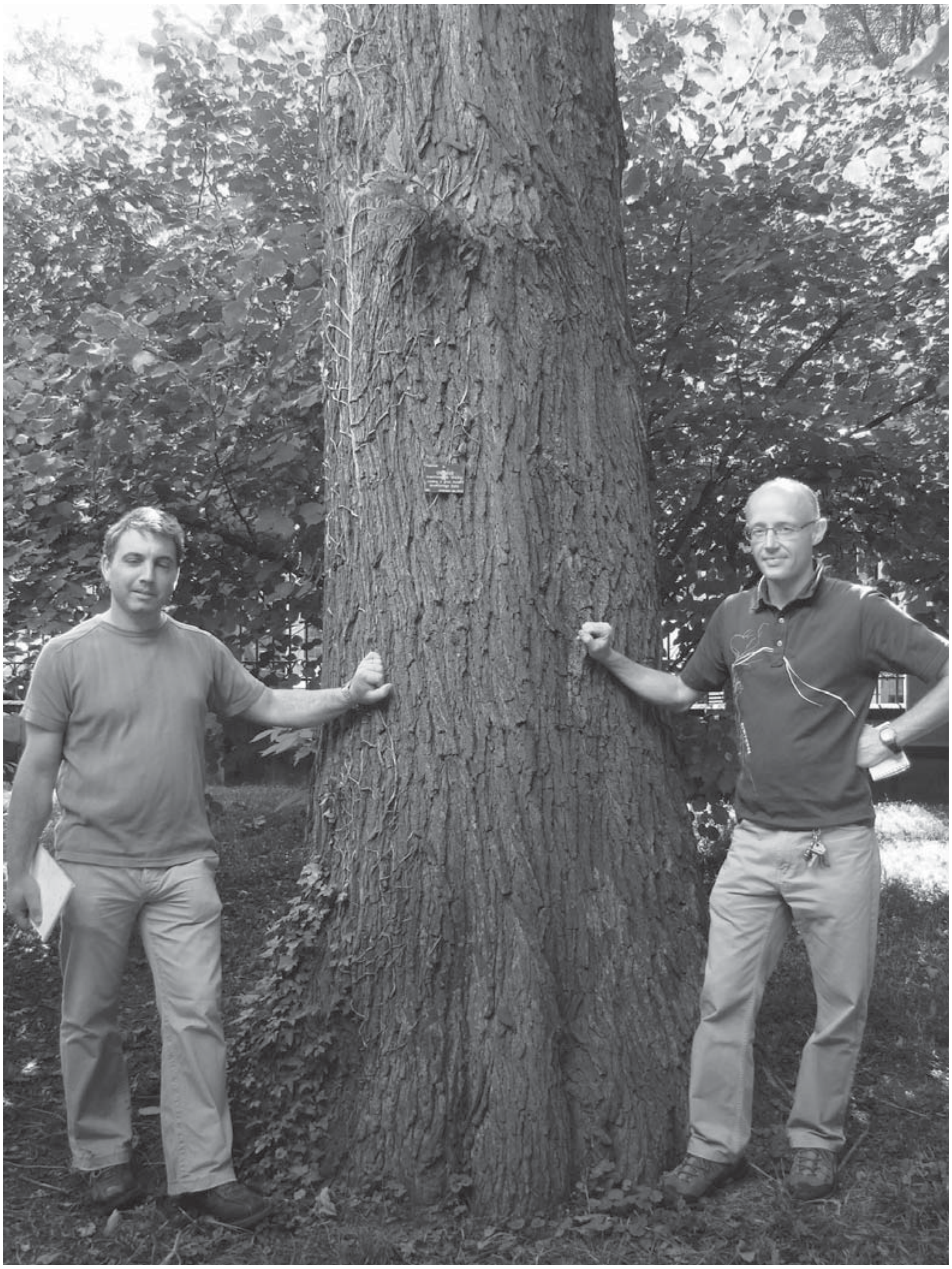

Fig. 5: Frédéric Tournay (left) and Christophe Grasse (right) with original *Quercus macrocarpa* 'Anton de Bary' at Strasbourg Botanic Garden.

selected for its uniqueness. Another seedling resembled *Quercus* × *turneri* Willd. whilst others have the habit of *Quercus ilex* 'Fordii'. The 37 year old plant has reached only 4 x 1 m. Standard Specimen: Harold Hillier Herbarium (HILL), Standard Specimen No. 6809, E.J.Jablonski 08082001, 20 August 2008, collected together with Piers Trehane and André Charlier. Named by Charlier after the operatic soprano Sebrena Gurinak. From the original plant, at Arboretum Rond Chêne, Esneux, Belgium.

France

Quercus macrocarpa Michx. **'Anton de Bary'** (Figures 5, 6). New cultivar and new cultivar name. A selection made at Strasbourg Botanic Garden for its fastigiate growth. It was possibly planted around 1880 at the time of foundation of

Fig. 6: Original *Quercus macrocarpa* 'Anton de Bary' at Strasbourg Botanic Garden.

the garden. Leaf blade obovate to narrowly elliptic, 70 - 120 x 60 – 130 mm, base cuneate, margins moderately lobed, toothed, deepest sinuses near midleaf; petiole 12-20 mm. In September 2008 the tree was 30 x 10 meters, girth (at 100 cm): 295 cm. For nearly 110 years this tree remained "undiscovered" and was for decades labeled as *Quercus macranthera*. It shows a strong fastigiate growth and thus was selected to be propagated vegetatively. Named by the present curator of the living collections, Frédéric Tournay, to commemorate the founding director of the Botanic Garden, Anton de Bary (1831 – 1888). Standard Specimen: Harold Hillier Herbarium (HILL), Standard Specimen No. 6650, Frédéric Tournay 20070007, August 2007. In cultivation in nurseries in France and The Netherlands. Figure 5 shows the trunk of the original tree with Frédéric Tournay (curator of Strasbourg Botanic Garden) and Christophe Grasse (head of Arboretum); figure 6 the original tree situated in the Garden.

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Some marginal populations of Holm Oak (*Quercus ilex* L.) in France

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Introduction

The Holm oak (*Quercus ilex* L.) is a species which is present in the South and Southwest of France, and its populations are considered among those growing under the harshest of ecological conditions. The Atlantic populations are in fact those located at the northern limit of the natural distribution of the species.

After recapitulating the morphological characters and the ecological requirements of the Holm oak, this article goes on to describe some populations which are marginal in terms of their geographical location and site characteristics. This polymorphic species is adapted to very different ecological conditions. It will be possible to monitor these populations developing dynamically in response to both recent and future climate modifications.

Morphological characteristics

Systematically the Holm oak (*Quercus ilex* L.) belongs to subgenus *Quercus*, section *Quercus*, the so-called white oaks. It is a very polymorphic species both with respect to its general aspect and to its vegetative structures relative to conditions at the sites where it grows. Its height thus varies between fifteen and thirty m with a maximum trunk girth of two m wherever the soil is sufficiently moist or where it benefits from a maritime climate. Its top is therefore spreading and spherical, while the trunk is generally short and thick (Le Hardÿ de Beaulieu *et al.,* 2007).

The species can also assume the aspect of a flattened suckering shrub, hardly exceeding 2 m in height, a bit like *Quercus coccifera* L, the Kermes oak of limestone scrubland. Its foliage persists from three to four years. The mature bark is rather thin and in the form of small scales more or less quadangular in shape. The twigs display a dense whitish-gray tomentum which often persists until the second year. The buds are small, round or somewhat ovoid, tomentose and possessing stipules which are quickly shed.

As to foliage, the Holm oak is probably one of the most polymorphous species in the world, including on the same individual or the same branches. The lamina is elliptical and almost orbicular. It measures 2.9 cm long by 1.6 cm wide. The leaf margin is entire or endowed with acuminate, mucronate, or wavy teeth/lobes. When the leaves unfold they are covered with an ashen gray or whitish gray tomentum on both surfaces; the upper surface becomes dark green, shiny and usually quite glabrous while the lower surface is covered with a fine but dense whitish or grayish tomentum. There are from seven to twelve secondary veins. The petiole is very tomentose and its length is between 0.3 and two cm. The caps are campanulate to almost hemispheric, from 0.7 to 1.7 cm in height by one to 1.5 cm in width. They cover between a third and a half of the acorn. They are composed of tomentose, grayish scales, small and imbricate. The acorns are ovoid to global, 1.5 to 3.5 cm high by one to 1.5 wide. They are solitary or arranged at most in groups of three on a fruiting peduncle measuring between 0.8 and five cm in length. The acorns ripen in a single season. The first crop is produced toward the age of twelve years and acorn production is abundant and regular until an advanced age. The size of the crop is tied to the amount of precipitation in the preceding autumn.

The Holm oak hybridizes with *Q. coccifera* L., *Q. pubescens* Willd., *Q. robur* L, *Q. rotundifolia* Lam., and *Q. suber* L.

Ecology

The Holm oak is adapted to a great variety of soils because it is indifferent to soil chemistry. Thus it is found on limestone soils which may or may not be decarbonated, compacted or loose, marly or alluvial, sandstone, schist, basalt, dry soils or such as are somewhat wet but readily draining (Rameau *et al.,* 2008). On poor or dry soils its growth is slowed. The presence of rocks or pebbles makes no difference. It prefers, nevertheless, terrain which is permeable and somewhat compacted. In the mountains it prefers slopes with a southern exposure.

The Holm oak grows from sea level to 2900 m in North Africa. Very tolerant with respect to soil, the same applies with respect to light, even if, as is well known, its development is maximal in the absence of forest cover. Nevertheless, it tolerates rather well the shade of cedars, beeches and pines. Although it loves heat, the Holm oak is not properly speaking a typical Mediterranean species, even though it moves in quickly after a fire. In essence, it is both Mediterranean and South Atlantic in nature. It therefore attains is most attractive dimensions close to the ocean and particularly in a maritime climate as is shown by its size in cultivation, notably in the United Kingdom.

The Holm oak endures summer dryness and the variations of Mediterranean climate without difficulty, as well as intermittent winter cold and prolonged summer dry spells. Depending on its situation, it lives with an annual rainfall of between 250 and 1000 mm, but it does not like regions which are cold and humid at the same time. It is not bothered by snow. It is a robust, vigorous and adaptable species, accepting of dry summers thanks to its tap root with well-developed ancillary roots, penetrating to a depth of ten meters according to Aimée Camus (1936-39).

Among plants which are companions of *Quercus ilex* are the following trees and shrubs: *Pinus pinaster* Aiton, *Pinus halepensis* Mill., *Arbutus unedo* L., *Pistacia lentiscus* L., *Pistacia terebinthus* L., *Quercus coccifera* L., *Quercus pubescens* Willd., *Quercus suber* L., *Ostrya carpinifolia* Scop., *Acer monspessulanum* L., *Acer campestre* L., *Buxus sempervirens* L., *Cistus laurifolius* L., *Cercis siliquastrum* L. and *Cotinus coggygria* Scop.

Fig. 1
Range of the
Holm oak.

Natural distribution

The Holm oak is a native of southern and central Europe and of the Mediterranean Basin: Albania, Algeria, Greece (including Crete), Italy (including Sardinia and Sicily) Libya (north-east), Macedonia (south), Morocco, Portugal, Spain, Tunisia, Turkey, the former Yugoslavia (west). Its presence in Israel, Lebanon, Syria, and Cyprus is due to human action. From north to south, its area of distribution is between 32° and 47° north latitude to 7° 45' west to 33° east longitude. It is precisely in France that its most northern populations are located.

In France, natural populations are found on the west coast as far north as the Loire estuary, while in the south east, these occur along the Mediterranean coast in populations which tie together the Massif Central and the Pyrenees mountains from sea level to 1500 meters, reaching 1200 meters in Corsica.

Description of some marginal populations in France

Ore (Haute-Garonne): This population is located at a relatively low altitude (450-600 m) facing west south west. It is situated primarily in the National Forest (Fig. 2) of the Frontignes in the communes of Galié and Ore. This population and its associated flora are the object of management and specific kinds of protection. It is located barely fourteen kilometers north of the Spanish frontier and the Pyrenees Mountains, whose nearest high peaks reach 2193 m. Characteristics of the local climate are a mean annual temperature of 11.4˚ C and a moisture regime of 1191 mm maximum per year. The absolute minimum is -14° C and the maximum recorded temperature is 37.5° C. This forest was identified by the biogeographer Henri Gaussen, whose name is perpetuated in the specific epithet of a conifer (*Pseudotsuga sinensis* Dode var. *gaussenii* Silba) and who was the founder of the Jouéou Arboretum located close by; this arboretum is devoted to gymnosperms.

Fig. 2. Holm oak at Ore.

The flora which surrounds this population is temperate montane; but due to its exposure and its limestone substrate, there occurs in this very localized sector a Mediterranean flora analogous to plant communities of this type located more than 200 kilometers to the east. Thus, for the southwestern part of France, this population is one of the most distant from the Atlantic Ocean (190 km). (Fig. 3)

We are thus concerned with stations which are very localized and isolated, subject to microclimates which contrast notably with those of the immediate surroundings. Particularly frequent is the foehn effect. This phenomenon occurs when the wind, after crossing the Pyrenees, drops down north of the mountains bereft of its moisture, becoming then hot and dry.

Tourettes sur Loup (Alpes Maritimes): One of the most beautiful Holm oak populations in France is found in the Alpes Maritimes, more precisely in the valley of the Loup in the commune of Tourettes sur Loup. It is situated in a generally Mediterranean context, between 950 and 980 m. It grows in scree at the base of a high limestone cliff, below the Pic des Courmettes, which reaches a height of 1248 m.

The last time we visited these trees was in the autumn of 1999 during an IOS "Oak Open Days." Some twenty individuals can be counted there whose circumference measures between 4 and 4.85 meters. The most interesting individual, called "Big Oak," measures 5.4 meters in circumference. (Figs. 4 & 5) The height of the trees is important for the species, since they are between twenty and twenty-five m. These trees, survivors of an epoch when charcoal was produced, were spared the frequent coppicing connected with the production of charcoal, whose excellent quality was well known for this species. Their age has been estimated between 700 and 1,000 years, which would make them the oldest for this species in France. This is probably because of the shelter provided by their canopy while charcoal stacks were being assembled, but it is also possibly for reasons of acorn harvest that these trees have survived until today. In this place, the average

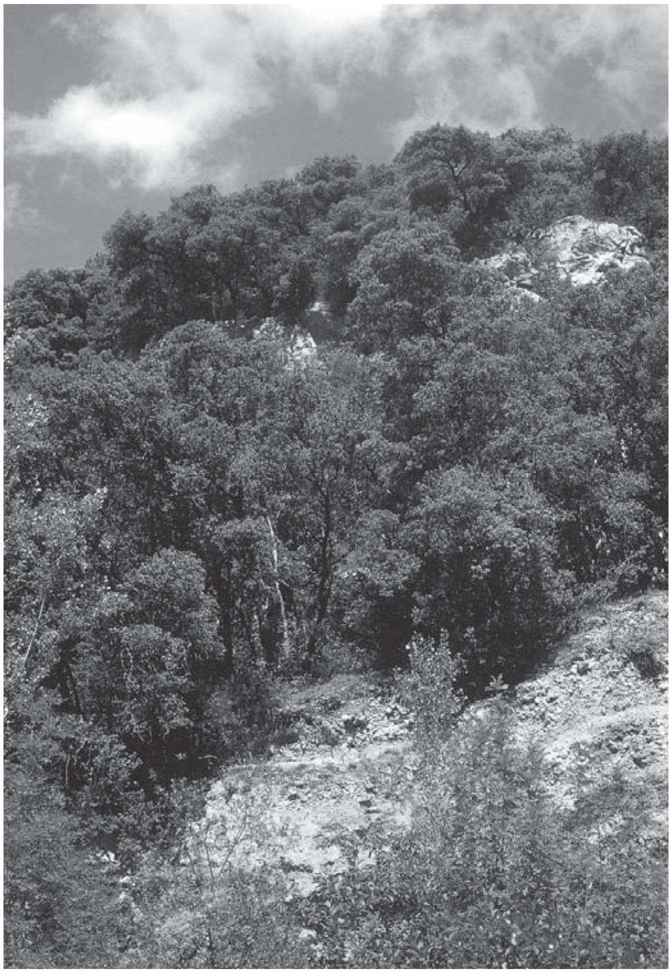

Fig. 3. Holm oak at Ore.

annual temperature is 12.8° C with an average minimum of -2.3° C. The annual average rainfall is 968.6 mm.

Also found here are magnificent examples of *Quercus pubescens* Willd. The size of these trees is explained by the presence of abundant subsurface water in the form of a subterranean river which lies above a layer of clay. This water layer surfaces in at least two places, and provides them an abundant supply of water at the level of their roots, which proliferate in deep marls rich in mineral elements. These springs empty farther away in a small marsh (Anonymous 1965).

Fig. 4. Holm oak in Alpes Maritimes.

Fig 5. "Big Oak," Alpes, Maritime.

The Haut Conflent (Pyrénées Orientales): The forested massif of Madres-Coronat is between 400 and 2400 m and lies 60 km west of the Mediterranean Sea. This forest features a plant community where *Quercus ilex* is scattered and associated with white oak (*Quercus pubescens* Willd.), junipers (*Juniperus communis* L.; *J. sabina* L.) and *Genista cinerea* DC. These evergreen forests occupy only 3% of the total area of the massif, which is to say about 600 hectares, facing south and east on limestone soils. In another sector of this forest, on soils dominated by limestone or schist, we can observe other old-growth or post-pastoral populations up to 1300m elevation. On the uphill side, these populations are in contact with secondary growth resulting from grazing on moors where Provence broom (*Cytisus purgans* Spach) is dominant. The uses of this forest, both at present and from time immemorial, are for grazing and extraction of forest products.

The climate characteristics are as follows: mean average annual temperature is 10.15° C and average annual rainfall is 780 mm; average of coldest month 0° C and hottest month is 24° C.

Other sites are also possible but more difficult of access; one such is the north slope of Mount Canigou (2784 m); on a site not too far distant from Mount Canigou, Holm oaks occur at 1560m. Expansion of these populations of Holm oak have been particularly perceptible during the recent past.

Mount Aigoual (Gard): This site is an example of a population of *Q. ilex* at its climate limit. In 1939, Aimée Camus published the second of the three volumes of her imposing monograph on the genus *Quercus* composed a year earlier. On page 88, she indicates that *Q. ilex* occurs in a "stunted form on the slopes of Mount Aigoual, between 1100 and 1300 meters, rarely fruiting." In reality, after consultation with different naturalists who possess information, we learn that these oaks do flower but it is unknown whether they actually reproduce sexually (Fig 6).

These oaks remained somewhat forgotten until several naturalists regained an interest in them well after the Second World War. These individuals, of small size, have indeed been seen in a rather restricted perimeter located near theArboretum de l'Hort de Dieu, which was established in 1902 by the forester Georges Fabre and the botanist Charles Flahault. The goal of this arboretum was to identify forest species useful for restoring the mountain forest of Aigoual, all but destroyed by decades of heavy exploitation. But no *Q. ilex* were planted in the arboretum, and their presence is therefore not connected to the eventual nonnative plantations. In fact, these oaks can flower, but it is unknown whether they can reproduce sexually (Fig. 7).

The precise location of these trees is somewhat vague. During 2008, after several unsuccessful efforts, we were able ourselves to locate some of these oaks between 1208 and 1219 m. Their GPS specification is as follows: between 44° 11'28" and 44° 11'30" North and 3°58'36" and 3° 58'42" East.

On this site the annual average rainfall is 1947 mm (in 125 days) and the temperatures are as follows: annual average, 6˚ C, minimal average 3, 02° C, maximal average 6,98° C. Furthermore, it is important to note that the annual average temperature at the summit of Mount Aigoual (where the meteorological station is located) has increased 2° C between 1980 and 1990.

The oaks are found at the edges of steep cliffs which are of difficult access on the southern and southeasten approaches. The rock is schist and the pH here is acid. The slopes belong to the basin of a small river, the Herault. The growth of the oaks is rather slow, and that year, there was no acorn production even if the flowers had been fertile. We do not know if these individuals are capable of

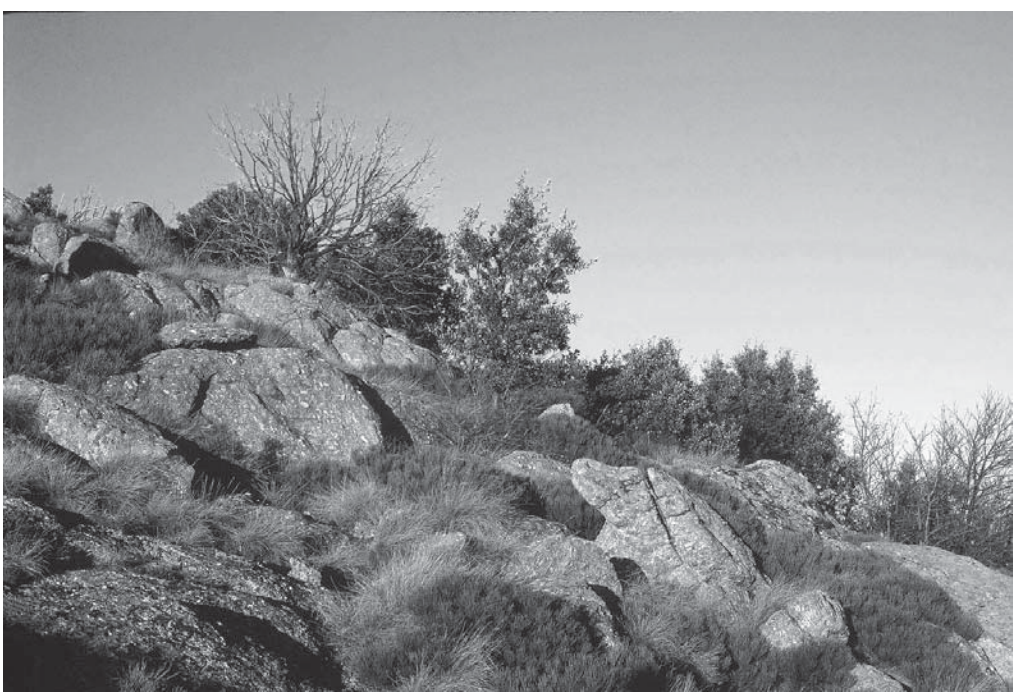

Fig. 6. Holm oak on Mount Aigoual.

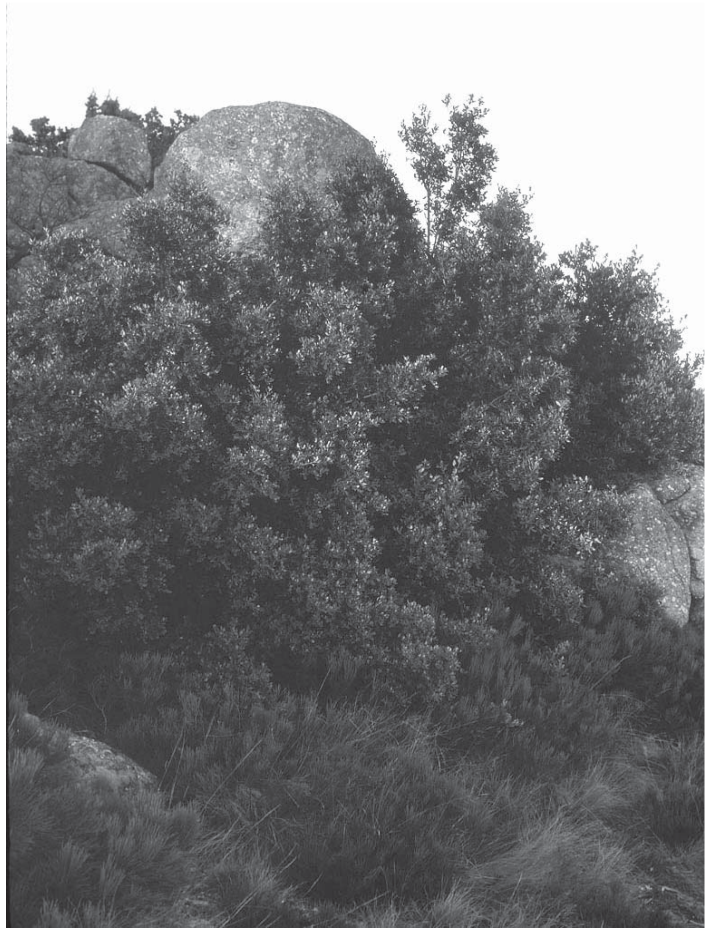

Fig. 7. Holm oak of Mount Aigoual.

producing viable acorns. However, the evident evolution of temperature due to global climate change suggests that opportunities for successful fruiting will be much more frequent in the future than in the past (Fig. 8).

From now on, these trees will be monitored regularly by local botanists and foresters. The largest of the group is about 2.5 meters tall. These specimens are stunted and rather spreading. In view of their dimensions, we think that Aimée Camus must have been referring to other specimens which have since disappeared (landslides, frost?) or else which have not been rediscovered. On the other hand, we know that their presence is to be regarded as the result of dissemination by the oak jay (*Garrulus glandarius* L.) from natural populations on nearby meadows and hills.

These oaks may also originate from acorns from a population identified at 900 meters some 10 km away on rocky granite of acidic pH on a south-facing slope. This latter group consists of rather vigorous shrubs, wider than high and fruiting regularly. They are located to the north of the community of Mandagout on the road which leads to Mount Aigoual passing over Luzette Pass at 1350 m. The mean annual precipitation varies between 1300 and 1500 mm and the lowest mean recorded temperature is -10°C.

The dynamics of this population are vigorous but this phenomenon is relatively recent. In fact, fruiting of these oaks was not observed before the 1980's. Since then, and because of the abandonment of extensive grazing, which has allowed

Fig. 8. Holm oak on Mecliffs of Mount Aigoual.

the growth of seedlings, these oaks are noticeably thriving in the midst of low shrubs of *Cytisus purgans* Spach, the Provence broom (Fig. 9).

This group constitutes at present (and in the absence of contrary information) the highest fruiting population of this region, where the minimal mean temperatures are probably the lowest in winter for this species in France. Moreover, these minima of long duration are much more frequent than at lower altitudes, where they also occur on occasion.

There also exist, on this same road leading to Mount Aigoual, two other isolated individuals growing under pines, a bit above 1000 m. No fruiting was observed,

Fig. 9. Holm oak and Provence broom.

possibly also because of low light resulting from shading.

Naturalized populations of Burgundy: The Holm oak was identified by F. Bugnon in Burgundy in the 1960's in the departments of Cote d'Or as well as in Saone-et-Loire. These trees must be naturalized individuals, because they are located about 260 km to the north of the northernmost populations of *Quercus ilex* in the Mediterranean zone of France, but at about the same latitude as the most northern natural populations on the Atlantic coast. In the Cote d'Or, not far from the wine-producing regions, these oaks have been observed on cliffs and upper limestone slopes in the municipal forest of Chambolle-Musigny and earlier at Gevrey-Chambertin (between 360 and 400 m above sea level with geographical coordinates 47° 13'N and 4° 56' E). In this area, the annual mean temperature is 10.8° C and although oriented toward the South, these cliffs experience low temperatures in winter (-19.5° C) while they reach 40° C in summer. The mean annual precipitation is 754.3 mm.

These oaks have been disseminated by jays from individuals planted in private parks (e.g. in the vicinity of Château and Chassignole and near the Rock of Solutré in the forest of Milly Lamartine) during the course of the 19th and the early 20th centuries. They have enjoyed good conditions for proliferation on these sunny limestone slopes. Nevertheless, the especially harsh winters of 1956 and 1985 (the extreme minimum recorded and cited before is -19.5° C) are probably the reason for the ultimate failure of these spontaneous attempts at wider colonization, the more so because of long periods of deeply frozen ground. This was the case for the rather puny shrubs of the community of Messigny, where at least one individual observed there in 1980 was noted as missing in 2009. However, several shrubs survived these harsh winters and were noted in 1997 and in 2002 on the heights of limestone cliffs at the village of Santenay at the place called "la Montagne des Trois Croix" ("the Mountain of the Three Crosses"). Can this be the beginning of a future colonization? Will the Holm oak be able to naturalize on these limestone cliffs and to increase its range beyond its current natural limit? This situation will certainly bear watching.

Conclusions

In France the Holm oak is under utilized. Its heavy wood is little used except for heating fuel and for charcoal. It could also be used as a fire wall in the Mediterranean region thanks to its wide and dense crown, as could also *Quercus suber* L, the so-called Chêne liège or Cork oak. However, it is mostly as an ornamental, after more than a century of absence, that this tree is slowly becoming of interest among professionals and managers of urban green spaces.

It is possible to suppose that the rise in mean temperature during the last decades, together with a favorable human context (establishment of reserves, cessation of cultivation) would permit the Holm oak, even though dependent on oak jays for its dispersion, to extend beyond its present area of distribution and to become a prominent player in forestation in the next few years.

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Inventory, Use, and Distribution of Genus *Quercus* in La Estacada, Municipality of Tixtla, Guerrero, Mexico

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Introduction

Quercus forests are located in the mountain areas of Mexico and occupy 5.5% of the country's surface. The oaks are in decline, owing to their exploitation for charcoal which has considerably reduced their distribution. Some of their former range has been converted into agricultural and pasture lands, often leading to erosion. In the state of Guerrero, considering the importance of oaks for firewood, it is necessary to study in depth their diversity and distribution through intensive regional collection.

Background

Within Mexico, there are 186 species of *Quercus* with a wide distribution. In Guerrero, the knowledge of this genus has increased remarkably in the last decades (Martínez 1978, Soto 1982, Gómez 1989, Valencia 1995). It is estimated that 29 species are found in this southern state. The state's central region stands out in its diversity of oaks, 26 of the total number of species being found there. Although the number of species in Guerrero seems conservative, the importance of some of them is due to their restricted distribution in which populations with rare individuals are found, and to the fragility and threatened status of some of their habitats, as is the case with *Q. corrugata* Hook., *Q. insignis* M. Martens & Galeotti, *Q. rubramenta* Trel., *Q. crispifolia* Trel. and *Q. nixoniana* S. Valencia & Lozada-Pérez.

Ortíz (1991), Monroy (1991) and Bustamante (1991) have referred to the use of oaks as fuel and have suggested strategies for much saving of energy as fuel and the improvement of the lumber industry with the objective of reducing the felling of trees. Similarly, Arias (1996) analyzes the use of wood for obtaining energy in Guerrero. The author concludes that the wood is employed in the preparation of food, the heating of water, the heating and lighting of living spaces, for sweat baths ('baños de Temaxcal'), as well as small manufacturing industries such as brick makers, tile manufacturers, ceramic workshops, lime makers, mezcal distillers, bakeries and restaurants.

Other studies mention the importance of oaks for the supply of firewood in different regions of the state (Cárdenas 2000, Carreto 2001, Gadea 2002). Among the floristic and vegetation studies, Reyes and Morlet (2006) report in the ejido Carrizal de Bravo, 15 species of oak and 4 indeterminate species, while Velásquez *et al.,* (2004) report for the area between Chilpancingo and Tixtla 12 species, 2 affinities and one specimen without identification. In particular for the community of La Estacada, Barrera (1998) did an ethnobotanical study of the medicinal plants in which she reports the use of *Q. acutifolia* Née and *Q. conspersa* Benth. for medicinal purposes; Godines (1997), in her study of edible plants, reports the alimentary use of *Q. castanea* Née and Candela (2001) focused his study on the diversity of the Tropical Deciduous Forest in the region.

Objective

To create an inventory, to know the use, distribution and the ecological importance, as well as to estimate the rate of extraction of the genus *Quercus* in the community of La Estacada within the municipality of Tixtla, Guerrero.

Methodology

Collections were made throughout the study area, in the areas of clear dominance by oak groves as well as the ecotone zones with Tropical Deciduous Forest. The physiographic characteristics were obtained and data wert recorded to obtain the value of importance (VIE) of the species that form the *Quercus* forest. For this activity, 12 15×15 meter parcels distributed in the four quadrants of the study area were selected. The data for obtaining the values of importance were processed in accordance with Brower and Zar (1980). With the help of aerial photographs, distribution maps for the species were elaborated. The map locating the *Quercus* forest and uses of the soil and vegetation were also constructed.

The field trips usually were done with local inhabitants to whom questions about forms of use as well as about family expenditures and sale of oak wood could be asked.

Results

The community of La Estacada and its surroundings are in the Sierra Madre del Sur between the population centers of Tixtla and Chilpa (Figure 1). It is part of the named region Hydrologic River Basin of Balsas as well as Political Region of the Center of Guerrero. It is between 17º 33´ 26" and 17º 36´ 42" latitude north and 99º 16' 20" and 99º 20' 0" longitude west at altitudes from 1,500 to 2,160 meters above mean sea level with an area of approximately 2,418 hectares.

List of Species

Seven species and one affinity were recorded. Three of these belong to the section *Quercus* (white oaks) and five to *Lobatae* (red oaks).

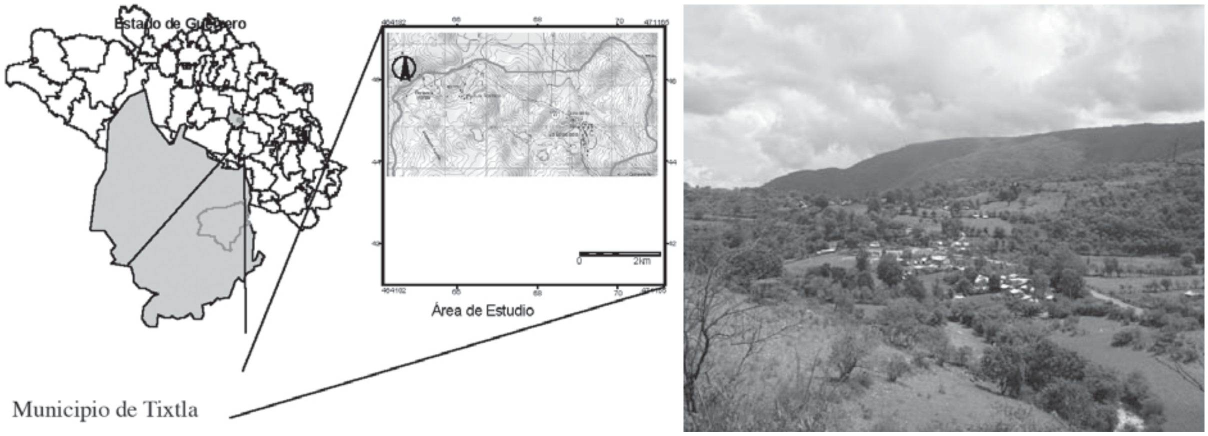

Figure 1: Location of the study area

Section *Quercus* (white oaks)

Series	Species
CIRCINATAE	*Q. liebmannii*
	Q. magnoliifolia
GLAUCOIDEAE	*Q. glaucoides*

Section *Lobatae* (red and black oaks)

Series	Species
ACUTIFOLIAE	*Q. acutifolia*
	Q. conspersa
CASTANEAE	*Q. castanea*
	Q. aff. *castanea*
SCYTOPHYLLAE	*Q. scytophylla*

Economic Importance of the Oaks of La Estacada

The analysis of the open-ended interviews and the surveys, as well as the direct observations, indicate that oak wood has a great economic importance for the community's inhabitants. The dry firewood is sold by units known as "cargas" (loads) which are equivalent to 24 logs and altogether weigh from 38 to 40 kilograms. Their commercial price is around MX$30.00 (1.76 US dollars). The other form is as "carga de monte" (woodland load) which weigh on average 80 kilograms and cost MX$60.00 (3.52 US dollars). The number of *cargas* that each family sells varies from one to 20 per month (5 to 10 $m^{3)}$ which is equivalent to from 36 to 720 *cargas* annually, with an economic income of MX$21,600 annually. Citizens of La Estacada sell this resource to bakeries, restaurants, and brick makers of Tixtla, Chilapa, Almolonga, Chilpancingo, Mazatlan and Tierra Colorada as well as outside individuals that solicit the sale. The oaks in larger demand are: *Q. liebmannii* Oerst. ex Trel.and *Q. magnoliifolia* Née owing to their caloric capacity and characteristic of giving off less smoke than the others. The lack of economic resources is the reason that forces the campesinos to sell their oaks. There does not exist a community management or control over the harvesting of wood since each *campesino* has assigned an area which is his to exploit. Each landowner decides the quantity, the season and the fate of the lumber. Official campaigns of reforestation do not exist and the regulation is not monitored. All the species of *Quercus* have different uses for the inhabitants. They appear to base their popular nomenclature on the characteristics of the wood.

Use of Soil and Vegetation

The type of vegetation predominant in La Estacada is *Quercus* forest which covers 1,569.4 hectares, corresponding to 64.9% of the total area of the community. Following it in importance is the area dedicated to seasonal agriculture, 499.19 hectares, which corresponds to 20.6%. The principal cultivars are: maize, squash, pachayota and garbanzo beans for their own consumption, though, sometimes, the inhabitants sell them outside of the community.

Floristic composition

In general, the oaks of the study area are distributed in elevations between 1,650 and 2,160 meters above mean sea level with a semi-hot, sub-humid climate, in which develop soils that are in color black, reddish and yellowish (luvisols, litosols and rendzinas). Oaks are found in flat lands, slopes, hillsides and on hill tops and in ravines where the most important factors which limit their distribution are altitude and humidity. The *Quercus* forest is composed floristically of species of *Asteraceae*, *Fabaceae*, *Mimosaceae*, *Poaceae* and *Lamiaceae* among the most important families (Figure 2).

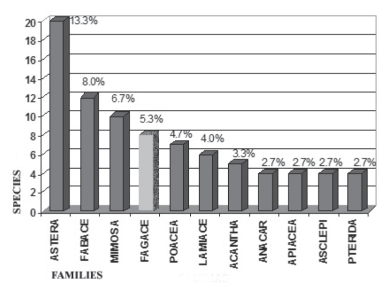

Figure 2. Main Families in the *Quercus* Forest.

The ecotone *Quercus* Forest intercalated with Tropical Deciduous Forest occupy 160;09 hectares, which represents 6.6% of the total area, where the species of *Q. liebmannii* Oerst. ex Trel., *Q. magnoliifolia* Née, *Q. acutifolia* Née, *Q. glaucoides* M. Martens & Galeotti, *Lysiloma acapulcense* (Kunth) Benth., *Ipomoea arborescens* (Humb. & Bonpl. ex Willd.) G. Don, *Dodonaea viscosa* Jacq., *Bursera bipinnata* (DC.) Engl., *Cercocarpus macrophyllus* C.K. Schneid., *Acacia pennatula* (Schltdl. & Cham.) Benth., *Pistacia mexicana* Kunth, *Eysenhardtia polystachya* (Ortega) Sarg. etc. predominate.

The Tropical Deciduous Forest occupies 114.45 hectares, equivalent to 4.7% of the total area. The representative species are: *Actinocheita potentillifolia* (Turcz.) Bullock, *Pistacia mexicana, Rhus galeottii* Standl., *Toxicodendron radicans* (L.) Kuntze, *Annona squamosa* L., *Oreopanax peltatus* Linden ex Regel, *Ostrya virginiana* (Mill.) K. Koch, *Tabebuia rosea* (Bertol.) A. DC., *Ceiba parvifolia* Rose, *Cordia* sp. *Bursera* aff. *fagaroides* (Kunth) Engl., *Bursera ariensis* (Kunth) McVaugh & Rzed., *B. bipinnata, B. glabrifolia* (Kunth) Engl., *Ipomoea arborescens, Arbutus xalapensis* Kunth etc. Other zones of minor importance are areas of “acahuales” (fallow land), the bodies of water devoid of material and human settlements.

Distribution of the genus *Quercus*

The oaks are distributed in almost all the study area with the exception of *Q. scytophylla* Liebm. (see Figure 4) which is distributed uniquely in the northeast and east part of La Estacada. Apparently the altitude (2,160 meters above mean sea level) is a limiting factor for the distribution of this species. Additionally it was observed that the dominant soil (luvisol) retains a greater quantity of moisture during the year. This condition may be related with the fact that the trees of this species do not lose their leaves in the season of low water (estiaje) in contrast with the other species.

Q. glaucoides M. Martens & Galeotti has a very restricted distribution. Uniquely it is found in the north part of La Estacada, sharing habitat with other arboreal species typical of tropical deciduous forest such as: *Lysiloma acapulcense, Dodonaea viscosa, Bursera* sp., *Brahea dulcis* (Kunth) Mart., *Ipomoea arborescens*, *Salvia* sp., *Rhus galeottii*, *Q. liebmannii*, among others. It occurs on the soil type known as rendzina: rocky with little humus with some drier zones. Probably the type of rock and soil would be the factors which restrict this species (see Figure 3).

The species *Quercus magnoliifolia* and *Quercus liebmannii* are those which display the higher Value of Ecological Importance (VIE), 108.16 and 49.21 respectively (Table 1). Ecologically they are more adapted to tropical conditions. Their distribution in these environmental conditions is favored markedly. It is observed that these species are also those which are more utilized in the homes and are commercialized.

There exist other species that show a high VIE and which are found sharing the habitat of the oaks, such as *Lysiloma acapulcense* (10.57), *Cercocarpus*

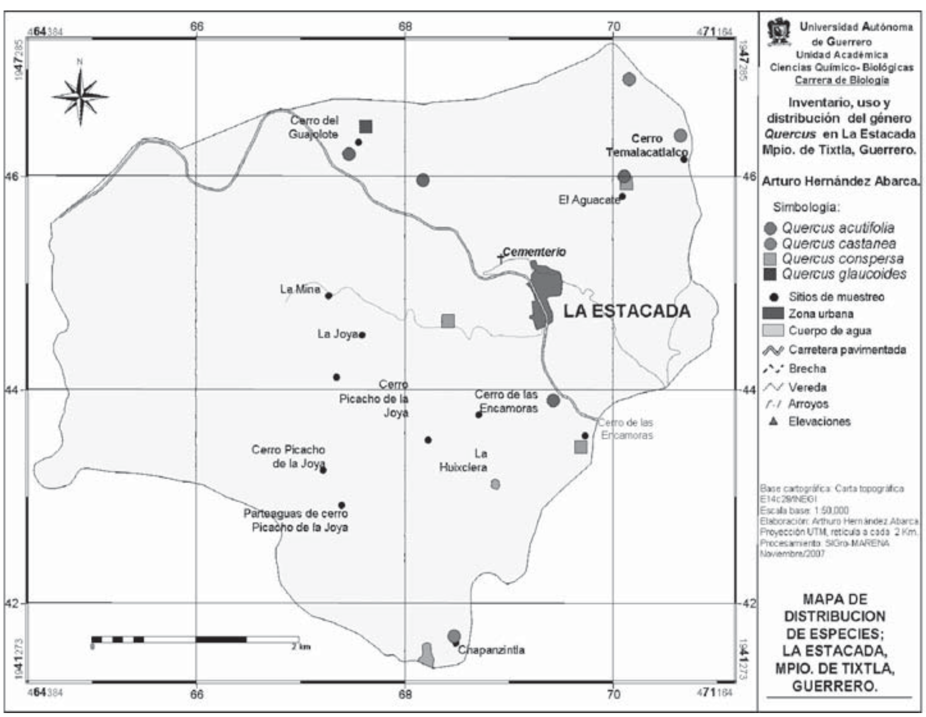

Figure 3: Distribution map for the species of *Quercus*.

macrophyllus (10.16), *Rhus galeottii* (9.97), *Mimosa pigra* L. (9.66), *Bursera bipinnata* (5.33), *Acacia pennatula* (5.23), among others, which altogether as a vegetative community play an important function ecologically: retaining humidity, preventing erosion, stabilizing local weather conditions and providing habitats for other plants and animals.

Conclusions

The oak forest is composed of seven species and one variety. Their habitats are basically tropical and are mostly deciduous. They are located from 1,600 to 2,200 meters above mean sea level on hills, ravines, steep escarpments, in shallow and deep soils: vertisols, luvisols and rendzinas. One important section of territory is encountered in the ecotone with tropical deciduous forest. The most important species ecologically are: *Q. magnoliifolia*, *Q. liebmannii*, *Q. acutifolia*,. and *Q.* aff. *castanea*.

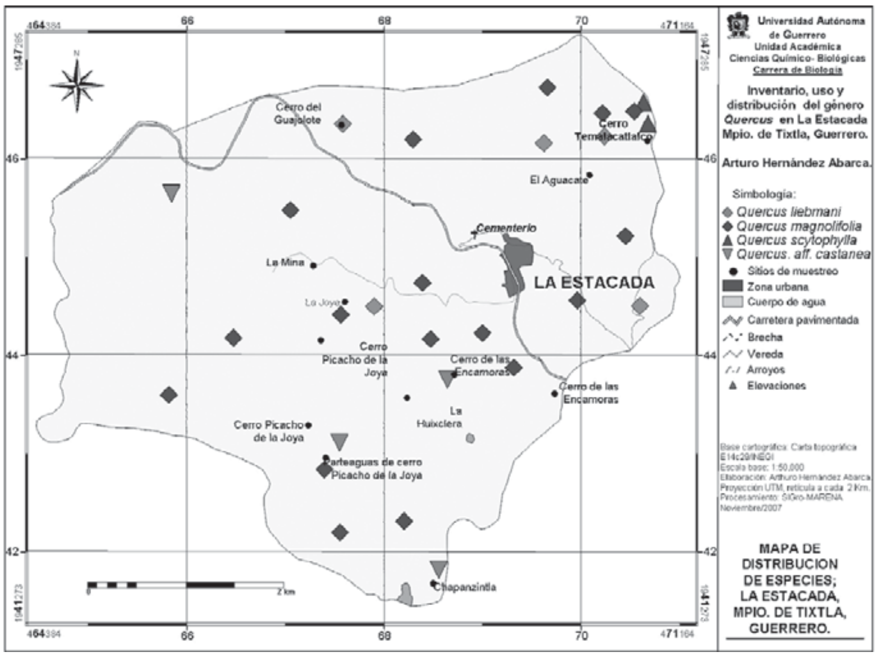

Figure 4: Distribution map for the species of *Quercus*.

The oaks in the locality have diverse uses. The wood is employed in the construction of houses, the handles of tools, posts for fences, a “chinancle,” or wooden screen, and in the elaboration of chairs for assembly. *Q. liebmannii* is utilized to cure diarrhea. *Quercus acutifolia* and *Q. conspersa* (Figure 5) are reported for curing burns, dealing with scorpion stings, and reducing deafness. *Q. castanea*, *Q. magnoliifolia* and *Q. scytophylla* (Figure 6) are used in the feeding of pigs and goats. *Q. castanea* is the only one reported for human consumption.

All the species have uses as fuel for which *Q liebmannii* and Q. *magnoliifolia* are preferred. The oaks supply the demand for energy for the heating of dwellings, for the preparation of foods and the obtaining of economical resources through the sale of firewood.

Thanks to Allen Coombes for assistance with review and translation.

Fig. 5. *Quercus conspersa*

photo©Arturo Hernàndez Abarca

Fig. 6. *Quercus scytophylla*

photo©Arturo Hernàndez Abarca

Table 1. Value of Ecological Importance of trees and shrubs in the *Quercus* forest in the community of La Estacada, Guerrero

Species	Num. ind.	DA	DR	FA	FR	Co.A	Co.R	VIE
Quercus magnoliifolia	**132**	**4.89**	**53.22**	**11.00**	**17.74**	**75.06**	**37.20**	**108.16**
Quercus liebmannii	**36**	**1.33**	**14.51**	**8.00**	**12.90**	**43.92**	**21.80**	**49.21**
Quercus acutifolia	**6**	**0.22**	**2.42**	**3.00**	**4.84**	**13.50**	**6.70**	**13.96**
Quercus* aff. *castanea	**4**	**0.15**	**1.61**	**2.00**	**3.22**	**17.40**	**8.62**	**13.45**
Lysiloma acapulcense	6	0.22	2.42	4.00	6.45	3.50	1.73	10.57
Cercocarpus macrophyllus	6	0.22	2.42	3.00	4.84	5.80	2.90	10.16
Rhus galeottii	10	0.37	4.03	3.00	4.84	2.20	1.10	9.97
Mimosa pigra	5	0.19	2.02	3.00	4.84	5.70	2.82	9.66
Quercus glaucoides	**5**	**0.19**	**2.02**	**1.00**	**1.61**	**9.03**	**4.50**	**8.13**
Bursera bipinnata	3	0.11	1.21	2.00	3.22	1.91	0.94	5.33
Acacia pennatula	3	0.11	1.21	2.00	3.22	1.60	0.80	5.23
Quercus scytophylla	**2**	**0.07**	**0.80**	**1.00**	**1.61**	**5.30**	**2.62**	**5.03**
Actinocheita potentillifolia	4	0.15	1.61	1.00	1.61	2.80	1.40	4.62
Pistacia mexicana	2	0.07	0.80	2.00	3.22	1.20	0.60	4.62
* Espina de Judío (S/I).	2	0.07	0.80	2.00	3.22	0.20	0.10	4.12
Rhus terebinthifolia	4	0.15	1.61	1.00	1.61	1.61	0.80	4.02
Diphysa floribunda	1	0.04	0.40	1.00	1.61	3.70	1.83	3.81
Eysenhardtia polystachya	3	0.11	1.21	1.00	1.61	0.91	0.50	3.32
Dodonaea viscosa	2	0.07	0.80	1.00	1.61	1.00	0.50	2.91
Quercus castanea	**1**	**0.04**	**0.40**	**1.00**	**1.61**	**1.55**	**0.77**	**2.78**
Galphimia glauca	2	0.07	0.80	1.00	1.61	0.51	0.25	2.61
**Fresnillo (S/I).	2	0.07	0.80	1.00	1.61	0.30	0.15	2.51
*** Undetermined species	1	0.04	0.40	1.00	1.61	1.00	0.50	2.51
Ipomoea arborescens	1	0.04	0.40	1.00	1.61	0.64	0.31	2.31
Arbutus xalapensis	1	0.04	0.40	1.00	1.61	0.40	0.20	2.21
Asteraceae (S/I).	1	0.04	0.40	1.00	1.61	0.40	0.20	2.21
Prunus capuli	1	0.04	0.40	1.00	1.61	0.20	0.10	2.11
Bursera aff. *fagaroides*	1	0.04	0.40	1.00	1.61	0.20	0.10	2.11
Brahea dulcis	1	0.04	0.40	1.00	1.61	0.11	0.05	2.06
TOTALS	248	9.19	99.92	62.00	99.92	201.64	100.00	299.93

Source: Fieldwork, March 2007 – November 2007, La Estacada, Guerrero

DA: Absolute Density. FA: Absolute Frequency. Co.A: Absolute Cover. DR: Relative Density. FR: Relative Frequency. Co.R: Relative Cover. VIE: Value of Ecological Importance

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The Genetic Variability of *Quercus grisea* Liebm. in the Sierra Fria of Aguascalientes, Mexico

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Introduction

Quercus L. (oaks, encinos, robles) is the largest genus in the *Fagaceae* with approximately 500 species (Rogers & Jonhson, 1998), mainly distributed in temperate and subtropical regions of the northern hemisphere (Nixon, 1998). Mexico is considered a center of diversity for the genus, with 150-200 species (Rzedowski, 1981; Nixon, 1998), of which approximately 115 are endemic (González-Rivera, 1993). As Mexico is a center of diversity for the genus, it is important to know the evolutionary phenomena that occurred within the populations in terms of population genetics and dynamic diversity. Genetic diversity is the most important factor on which adaptation and evolution depend and its maintenance is vital to the mechanisms of reproduction, cross-breeding and dispersal in a population or evolutionary lineage (Amos and Harwood, 1998).

Genetic diversity is measured by the use of markers, either morphological or molecular and among the great diversity of molecular markers that exist micro-satellites should be emphasized as these, by their nature, show high variability between individuals. Microsatellites are repetitions of simple sequences from 2 to 10 pb, with a high rate of mutation and can be found in the DNA of the nucleus, mitochondria, chloroplasts and in other genetic material such as viruses, plasmids and transposons. Those of the nucleus show Mendelian inheritance and are co-dominant. Because of their capacity to differentiate between both individuals and large groups, microsatellites have been of great use in the analysis of parentage, allele distribution, genetic structure of populations and phylogenetic and phylogeographic studies (Hartl, 2000).

Identification of the level of variability of the species as well as the genetic dynamics of its population allows us to infer the state of conservation of the populations. High levels of variability are seen as healthy, conferring the capacity to respond to threats such as diseases, parasites, predators and environmental changes. Conversely, low levels of variability are seen as limiting the capacity of the species to respond to such threats in the short and long term (Amos and Harwood, 1998). The loss of genetic variability is associated with phenomena such as a reduction in population size, which can occur naturally due to several factors (for example catastrophes, high predation or a reduction in the reproductive capacity of the species. However, in recent years the reductions in the population size is more associated with loss of habitat and over-exploitation of natural resources as a result of human activities (Frankham *et al*.,, 2002).

In the Sierra Fria of Aguascalientes the oaks were subject to intense logging from 1920 to 1950 and suffered further from the development of extensive cattle ranches during second half of the 20th Century (SEDESO 1993; Minnich *et al*.,, 1994). There are several areas in the Sierra Fria with serious problems of erosion where the oak woods are very disturbed.

The zone is composed principally of two types of vegetation: oak-pine forest (about 64%) and pasture, *Quercus resinosa* Liebm., *Q. potosina* Trel., *Q. grisea* Liebm. and *Q. eduardii* Trel. represent about 74% of the tree cover (Márquez-Olivas *et al.,,* 2002). In 1995, this zone was declared as a zone subject to ecological conservation (ZSCE) and it was named by CONABIO as one of 153 terrestrial priority regions (RTP). Since then it has lost about 37% of the original vegetation (Arriaga *et al*.,, 2000). Recent studies using aerial and satellite photographs have shown that from 1956 to 1993 the vegetation cover has been maintained, however, it was also shown that some human activity such as the creation of new agricultural lands and grassland has been responsible for some forest and grassland deterioration (Chapa-Bezanilla *et al.,,* 2008).

Quercus grisea is one of the oaks that is abundant in the Sierra Fria forming forests on well-drained soils and is associated with juniper woods, oak woods and pasture. It is reported in three localities in two municipalities of Aguascalientes, one in the municipality of Calvillo and two in San José de Gracia (De la Cerda Lemus, 1997). The genetic study of this species can help us to understand the methods of dispersal that occur in the zone and to identify conservation zones in the Sierra Fria.

A great deal of work has been carried out in the world on the genetic diversity of oaks, including analysis of variability measured as an index, the detection of possible hybrids, phylogenetic analyses and phylogeographic studies, using a wide range of molecular markers from enzymes to sequence analysis. In the case of genetic studies on oaks using nuclear micro-satellites, contrasting results have been reported. Generally, genetic variability is found within the populations, which are not structured (Dodd & Kashani 2003; Dutech *et al*.,, 2005; Muir, 2004). However, works exist in which clonal structure is reported, such as that of Ainsworth and collaborators in 2003. In Mexico, pioneering studies have been carried out on the genetic variability of the group and its population structure, particularly those of Alfonso-Corrado *et al*.,, 2004, González-Rodríguez *et al*.,, 2005 y González-Rodríguez *et al*.,, 2006, in which the genetic variability and population structure of the analyzed species was measured.

Given the abundance of oak forests in the conservation zone of the Sierra Fria and that *Q. grisea* is one of the most abundant species, it is important to know the state of genetic conservation of their populations by evaluating the genetic variability as well as defining the populations that are more important in terms of gene flow. This will help us to understand more fully the mechanisms of pollination and dispersal that are common to oaks of the zone.

The objectives of this work are to estimate the level of genetic variability in the populations of *Q. grisea* in the Sierra Fria by the use of nuclear microsatellites, to identify the pattern of gene flow between populations and to define the populations that are most important genetically for ecological conservation.

As oaks are wind pollinated and long-lived, and as *Q. grisea* is an abundant species in the zone, it is hoped to find a high level of genetic diversity in terms of allele wealth. It is also hoped to find a high level of gene flow between neighbouring populations.

Materials and Methods

During May and June 2007 leaves of 84 individuals of *Q. grisea* were collected from four sites in the Sierra Fria, namely "Rancho el Cepo" (CP), "Entrada a la Congoja" (EC), "Mesa el Sapo" (ES) and "Mesa Montoro" (MT). Leaves were collected from at least 20 individuals at each site. The descriptions of the sites and the individuals included are shown in Table 1.

The sites were surveyed and data entered into the program Arc View v. 3.1 in order to calculate geographic distances.

DNA was extracted from leaves of 84 individuals using the protocol DNeasy Plant Kit de QUIAGEN and one of its modifications. Fragments were amplified by PCR for the primers 1F02, OC19 y OC11 of the series quru AG (Aldrich *et al*., 2002). The reactions took place in a volume of 25 ml, 1X Taq Buffer, 10mmol dNTPs, 20mMol MgCl2, 0.0001ug/L de BSA, 10ng de ADN, 0.5 u Taq polymerase and 0.72 nm of each primer F and R. The amplification was carried out in a Thermocycler Gene Amp PCR System 9700 set at 94° C 3 min, (94° C 10 sec. (denaturation), Tm° C 10 sec. (alignment), 72° C 10 sec. (extension) X 30 (cycles) and 72° C 3 min (complementary amplification). The products were run in gels of 1% agar, 115 V for 40 min and visualised with Ethidium bromide (BrEt) exposed to UV light, using a 100 pb molecular marker as a reference. The amplification products were diluted 1/40 w/w and 1 µl of the diluted amplified product was mixed with 9.75 µl HiDi Formamide and 0.25 µl ROX-500 or Rox400. The mixture was analysed in an ABI Prism 3700 (Applied Biosystems) using the method of analysis of fragments.

When the electropherograms were obtained, the size of each fragment was determined using the program Gene Scan Analyzer (Applied Biosystems). When the fragments had been identified, each one of the individuals was genotypified and the genotypes were entered into a database for genetic analysis. The calculations of expected heterozygosity (He), observed heterozygosity (Ho), genetic distance and index of endogamy (Nei, 1972) were carried out using the program TFPGA. The calculation of genetic flow was made from the estimator theta (Θ_{st}) from paired data between populations. The estimation of exclusive and represented alleles was made by a direct count.

Results

The loci OC19, 1F02 and OC11 were polymorphic for *Q. grisea* with variable sizes. Values are shown in Table 2. Genetically identical individuals were not found.

Table 1. Description of collecting sites.

Site	Municipio	Latitude N	Longitude W	Altitude m	Vegetation	Description	Number of individuals
Entrada a la congoja	San José de Gracia	22º 9' 39.4''	102º 32' 58.2''	2500	*Q. grisea* and *Juniperus depeana*	Flat pasture	20
Mesa Montoro	San José de Gracia	22º 00' 26.1''	102º 34' 25.6''	2384	*Q. grisea* and *Q. potosina*.	Flat with slight slope. Site used for cattle grazing	20
Mesa el Sapo	San José de Gracia	22º 14' 44.2''	102º 29' 31.4''	*	*Q. grisea* and *Q. potosina*.	Oakwood with flat areas, disturbed by cattle	21
El Cepo	San José de Gracia	22º 11' 06.9''	102º 35' 46.9''	2590	*Q. eduardii, Q. grisea* and *Q. potosina*.	Oakwood, slightly disturbed inside the hunting area	23

Table 3. Number of alleles, exclusive (E) and observed (O) for each locus per population.

	OC19		1F02		OC11		Total	
Site	E	O	E	O	E	O	E	O
CP	1	12	0	11	2	10	3	33
EC	6	17	0	10	1	10	7	37
ES	6	15	2	13	1	11	9	39
MT	6	12	1	12	1	10	8	34

Table 4. Heterozygosity expected (Ho) and observed (He) per allele and population for *Q. grisea*.

	OC19		1F02		OC11		Total	
Site	Ho	He	Ho	He	Ho	He	Ho	He
CP	0.5217	0.8483	0.6087	0.8048	0.9565	0.7971	0.7971	0.8167
EC	0.4000	0.9244	0.6842	0.8549	0.8421	0.8634	0.6421	0.8809
ES	0.4286	0.9338	0.6667	0.9024	0.9048	0.8676	0.6667	0.9013
MT	0.5500	0.8282	0.7222	0.9302	0.8500	0.7397	0.7074	0.7397
Average	0.4762	0.9181	0.6667	0.8886	0.8916	0.8255	0.6781	0.8774

Table 2. Relationship of fragments for the series *quru* GA in *Q. grisea*.

quru GA	OC19	1F02	OC11
No of individuals	84	83	82
No of loci.	31	17	15
Range in size.	198-382	140-242	190-224

The primer OC11 showed the highest value for a polymorphic locus compared to those reported in previous studies.

The number of alleles present in each population per locus per site and the number of exclusive alleles was variable between the populations with "Mesa el Sapo" showing the highest number of represented alleles. The data are summarised in Table 3.

The observed heterozygosity for all populations shows a high (0.6781) level of genetic diversity and corresponds to obligate outcrossing organisms. For the loci OC19 and 1F02 it can be seen that there is a deficiency of heterozygosity, in the case of allele OC11, it can be seen that the frequencies are in equilibrium. At the population level, the analysis is different, in that the 4 populations are very close to equilibrium between homozygosity and heterozygosity. The populations closest to equilibrium are CP and MT (Table 4).

The estimated coefficient of endogamy for all loci for all populations (Θ_{st}) is 0.0265, which is a low value and shows that the populations are not genetically structured and share gene flow between populations. This tells us that in genetic terms, the populations are very similar, that selection and endogamy are not occurring and the mechanisms controlling the genetic diversity between the populations, such as dispersal and pollination, are effective. From these data it can be deduced that the most similar populations are EC and ES, while the most different are CP and MT (Table 5).

In terms of genetic distance the populations CP, EC, and ES are statistically very similar, with MT the most different, as well as the population most distant from the others. This tells us that distance may be a factor in the genetic isolation of population MT. For the other populations distance is not a factor that causes isolation as the most similar populations are not the closest (Table 5).

Gene flow between populations tells us that it is greatest for populations EC and ES, which correlates with the genetic distance, i.e. what maintains the identity of each population are the mechanisms of dispersal and pollination (Table 5).

Table 5. Comparison of distance, geographic ($D_{geo)}$, genetic (D_{gen}, coefficient of endogamy (Θ_{st}) and gene flow ($N_e m$).

	D_{geo}	D_{gen}	Θ_{st}	$N_e m$
CP vs EC	5.61	0.2902	0.0237	10.30
CP vs ES	12.59	0.2901	0.0234	10.43
CP vs MT	19.81	0.4055	0.0487	4.88
EC vs ES	11.12	0.2905	0.0057	43.61
EC vs MT	17.23	0.4514	0.038	6.33
ES vs MT	27.95	0.3116	0.0198	12.38

Discussion

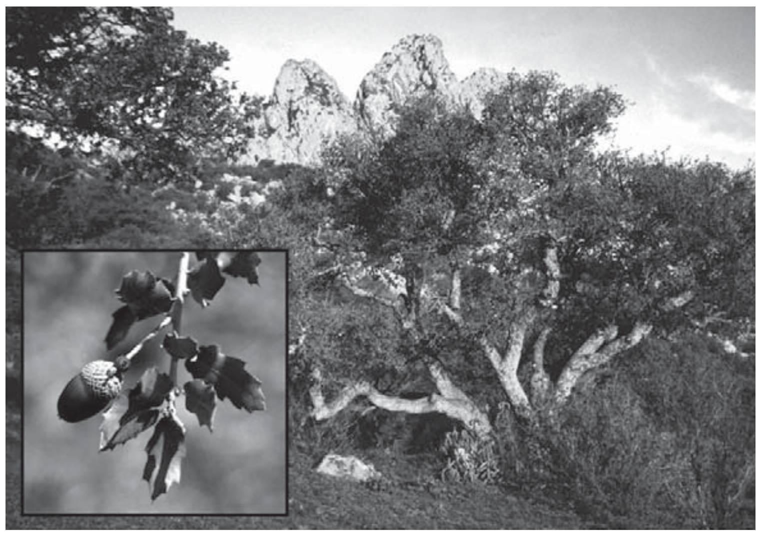
The observed genetic variability measured in terms of wealth of alleles shows that *Q. grisea* has a broad genetic variability. The locus *quru* AG OC19 showed a greater variability for an allele than the previously reported range of 10-14 loci. This shows that the marker is very good for studies of genetic variability and that the allelic diversity in the species is very high.

As all the genotypes proved to be different from each other it can be inferred that reproduction in *Q. grisea* is preferably sexual and by outcrossing. We did not sample from individuals close to one another, as we would expect to find genetically identical individuals because of the low number of loci used.

In the populations of "Mesa de Sapo" and "Entrada a la Congoja" were found most indications of allelic wealth, nevertheless the population of "Mesa Montoro" also has a high amount of exclusive alleles. The neutral theory in genetics of populations predicts that the greater amount of alleles is in populations of great size with ancestral distribution, indicating that these three populations are the candidates to be oldest and greatest in population size. The population of "El Cepo" could be the result of a recent colonisation. In order to verify this hypothesis, further studies of phylogeography by analysing sequences of the populations can generate demographic studies for each of the populations. It is possible to indicate that the three sites with greater allelic wealth are also associated with plains, oakwoods or pastures. This can be because the reproductive success in plains generates a high amount of individuals with the corresponding generation of new alleles by generation.

The heterozygosity data show that the populations are closely balanced between homozygosity and heterozygosity, and it can be deduced that at the interior of the populations phenomena of natural selection or intense processes of genetic drift or endogamy are not occurring. Nevertheless it was observed that loci OC19 and 1F02 show that there is a slight deficiency of heterozygosity that could denote a selection process, which it is being concealed by the heterozygosity of allele OC11. Although in general terms we cannot speak of a selection process among the heterozygotes, the deficiency of heterozygotes can be considered to be the result of a reproductive process such as endogamy acting on the populations. Another explanation is that the expected heterozygosity depends as much on the amount of alleles as their frequencies. If a high amount of alleles with low allelic frequency occurs, the index of expected heterozygosity should be high and as the population size used for the study is small it is possible to underestimate the amount of heterozygosity in the population because their frequencies are not equalled. Although the expected heterozygosity can be overestimated, the observed heterozygosity is a good estimator to identify the genetic variability, the average value for all the populations corresponds to the organisms with sexual reproduction and obligate outcrossing and is very similar to the values reported in previous studies for oaks.

The coefficient of endogamy is very low (0.0265) and shows that the populations are not structured genetically and are very similar to each other. This may be because wind can be very effective for pollination and that the pollination strategy of *Q. grisea* allows the exchange of gametes over large distances which causes the genetic maintenance of the species in the zone.



Quercus grisea photo©Guy Sternberg

The paired data for genetic distance as well as endogamy coefficient are very similar between the populations. The populations of “El Cepo”, “Entrada a la Congoja” and “Mesa el Sapo” in terms of distance, form a single group whereas “Mesa Montoro” is the most isolated population. The intensity of gene flow between “El Cepo”, “Entrada a la Congoja” and “Mesa el Sapo” may be causing its identity in genetic terms and large geographic distance may be a factor that limits the genetic exchange between populations. If oaks are pollinated by wind then it can be deduced that the effectiveness of wind as a pollinator is reduced when distances are great. Another factor that can alter the genetic flow between the populations is the presence of geographic barriers, and although “El Cepo” and “Entrada a la Congoja” are the closest populations to each other, they are not the most similar genetically. “Entrada a la Congoja” and “Mesa el Sapo” are the two most similar populations, probably because there are no mountainous barriers between these two and the distance between them is not great as it is between them and “Mesa Montoro”. It therefore appears that the main obstacle for wind pollination is firstly geographic barriers and secondly geographic distance.

In terms of conservation the population that meets the requirements of high allelic wealth, presence of exclusive characters and a high level of gene flow is

"Mesa el Sapo". However, if conservation efforts are directed solely to this one population there is the risk of losing exclusive alleles in the long term, as can also occur at "Mesa Montoro", the population with greater isolation in terms of gene flow. For this reason it is recommended that conservation efforts be concentrated on the populations of "Mesa Montoro" and "Mesa el Sapo" to conserve the greater allelic wealth as well as the greater amount of exclusive alleles. If the intensity of gene flow remains as it is today, the population of "Entrada a la Congoja" can remain as a corridor of alleles between both populations. It is likely that data related to population demography would be needed to plan the long-term viability of each of the populations.

A recent study has quantified the changes of ground use in the zone by analysis of aerial photos and of satellite images which show that from 1956 to 1993 the forest been neither reduced nor increased, that is to say the cover stays constant. Nevertheless, the same study also states that in terms of degradation of habitat in the Sierra Fria of Aguascalientes there is a tendency for the forest to increase (Chapa-Bezanilla *et al*., 2008). This is very important for the establishment of strategies of conservation in the zone. The "Entrada a la Congoja" is the population that has the greater risk of disappearing, as the study considers that there is a growth of induced cattle pastures that can affect population growth.

Conclusions

The genetic variability of *Q. grisea* in the Sierra Fria of Aguascalientes, in terms of allelic diversity, is high.

Evolutionary processes that act on the genetic diversity of the populations of *Q. grisea* in the Sierra Fria were not detected.

The populations of *Q. grisea* are not genetically structured.

The populations of "El Cepo", "Entrada a la Congoja" and "Mesa el sapo" can be considered in genetic terms as a single group, with the population of "Mesa Montoro" the most different genetically.

In the Sierra Fria, the processes of pollination and dispersal are very effective in maintaining genetic diversity.

In terms of conservation, the most important population is "Mesa el Sapo".

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Xochitla Botanical Garden: Experience with the Conservation of Oaks in an Urban Green Area in Mexico City

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Summary

This paper describes the Xochitla Botanical Garden's experience with the conservation of several Mexican oak species (two of them on the IUCN Red List). The project, which includes propagation, conservation, gardening, training, education and management, has provided a wealth of experiences and challenges, with a bearing on Xochitla's urban surroundings. We also draw attention to the importance of forming alliances with academic institutions and donor agencies to strengthen the project, which is aligned with the Global and Mexican Strategies for Plant Conservation.

Introduction

Xochitla, which is run by the Xochitla Foundation, is located north-west of Mexico City(19º42'30" N and 99º11'47" W), two miles from the district town of Tepotzotlán in Mexico State, Mexico. It is 18 miles from the 32,000-acre Sierra de Tepotzotlán State Park.

Under the 1986 urban development plan, almost 1,000 acres of town land were to be set aside as an ecological preservation area. However, in 1993 the state government earmarked the land for industrial use, with the result that Xochitla was soon left as a green oasis surrounded by warehouses (Martínez, 2008).

The transformation of its environment has increased the importance of Xochitla as an urban green area that gives local residents a better quality of life and helps maintain some of the region's biodiversity. Xochitla's mission is "*to develop, strengthen and guarantee for the benefit of society, and with its participation, the presence of an urban green area, where human beings can re-encounter nature and which we can all enjoy and learn from.*"

Urban green areas bring direct social benefits by, for example, reducing stress, encouraging integration and enhancing emotional relationships. They also provide a variety of environmental services, such as water infiltration, noise reduction and pollutant trapping, which, as a whole, improve a city's atmosphere and image. Because they also provide spaces for cultural activities, social interaction, recreation and environmental education, their importance seems sure to grow in the coming decades (Martínez, 2008).

Xochitla as an area of study

Geology: Alluvial fans of clastic andesite accompanied by argillaceous tuff, sand and gravel. The prevailing soil is argillaceous loam with a pH of 6 – 6.6.

Hydrology: Xochitla is included in the Cuautitlán hydrological region, which is drained principally by the Cuautitlán and Tepotzotlán rivers.

Climate: According to data from the Xochitla weather station and the Köppen climate classification system, the area's climate is **Cw_1 b (i') g** (Mercado and López, 2006). Subhumid temperate climate with summer rains, intermediate among subhumid climates, with a cool summer, percentage of winter rainfall 4.5, little temperature fluctuation. The hottest month is June, with summer drought.

Vegetation: Xochitla's flora is mainly secondary (53%), with species typically found in oak woodland, pasture, and drought-resistant scrubland. An inventory of the flora identified a total of 35 families, 110 genera, and 153 species. The best-represented families are Compositae, Gramineae, Leguminosae and Malvaceae. Twenty-three percent are species that can live in some types of primary, as well as secondary, vegetation. The remainder (24%) are typical of primary vegetation. This indicates that Xochitla has a certain degree of conservation, which would allow it to be rehabilitated by reforestation with species that are native to the area (Castro, *et al*., 1999 and Romero, *et al*., 2000).

Soil: The soils are deep with developed strata and high clay content. The clay strata have an average depth of 1.70m to 1.90m. The strata beneath them have a higher sand content. The major problems with the soil are compaction and low organic material content.

Fauna: There are 57 species of Lepidoptera (36% of the 158 species reported in Mexico State); six reptile and three amphibian species (6.5% of the herpetofauna found in the state); 98 species of birds; and 11 species of wild mammals (opossums, field mice, wild rabbits and bats).

Xochitla Botanical Garden

The 45-acre Xochitla Botanical Garden houses two main collections – the Arboretum, with species from Mexico's temperate regions and the aquatic garden – where the public can contemplate, appreciate, and learn from the rich biodiversity in the Basin of the Valley of Mexico.

The Xochitla arboretum dates from 1999. It was designed (according to Romero and Rojas, 2000) to:

1. Be a space for a significant diversity of native arboreal species typical of temperate and arid areas in order to demonstrate their environmental or cultural importance for the human race.
2. Encourage scientific research and projects on the arboreal flora.
3. Spread knowledge of the importance of trees, their functions and environmental benefits.
4. Be a wooded space of high esthetic quality, integrated into the region's landscape, which contributes to the consolidation of Xochitla's green areas.
5. Be an area where encouragement is given to new opportunities for recreation, with a strong emphasis on environmental education and awareness of nature.

These goals are in line with the main aims of the Global and Mexican Strategies for Plant Conservation: conservation, research (propagation, forestry and phenology, plant health), horticulture, training, education, and management.

*Conservation***.** With many of its species used in construction and industry and as food and medicine, the genus *Quercus* is one of the world's most important taxa. In our country, however, it is mainly used as firewood and to make charcoal (Romero, 1993).

Mexico is home to the world's greatest diversity of oak species (Zavala & García, 1996 in Romero and Rojas, 2000). More than 50% of Mexican species are endemic and the centre of the country is known as a major point of diversification, where, although many species thrive, others are endangered as a result of the severe reduction of the size of their habitat and consequent decrease in the number of individual trees (Zavala, 1998). Of the 23 species reported in Mexico State, eight grow in the nearby Sierra de Tepotzotlán, of which four are found in Xochitla.

The Master Plan for the Xochitla Botanical Garden recommends that the 23 species found in Mexico State be added to the collection, and 11 have already been planted in the Arboretum. The species are chosen according to their ability to adapt to the climate. Their nearby location reduces the cost of collecting acorns and makes it easier to compare differences between the trees in their natural habitat and those in the Xochitla collection.

Table 1. Percentage of species represented at Xochitla.

Reference	**Species represented at Xochitla**	**Species**	**%**
Mexico (country)	140	11	8
Mexico (state)	23	10	43
Sierra de Tepotzotlán	8	4	50

The IUCN Red List shows the oak species with some risk category worldwide. Two of the species considered to be in danger of extinction are to be found at Xochitla. These trees, which are endemic to the State of Mexico, are *Quercus germana* Schldl. & Cham. and *Q. hintonii* E.F. Warb. In the case of the former, seeds have been collected for propagation, and we currently have 22 healthy seedlings for use in reforestation.

Fig. 1. Acorns on a 12-year old *Q. rugosa*.

*Research***.** Research into propagation, forestry, phenology, and plant health has been given priority for the development of the botanical garden.

Propagation. With support from FES – Iztacala UNAM researchers, a project was executed in 1997 and 2000 to propagate *Quercus rugosa* Née*, Q*. *crassifolia* Bonpl.*, Q*. *scytophylla* Liebm.*, Q*. *obtusata* Bonpl.*, Q, crassipes* Bonpl.*, Q*. *castanea* Née*, Q*. *grisea* Liebm. and *Q*. *laurina* Bonpl. Germination tests showed a germinative capacity that varied between 91% and 97.2% (Romero and Rojas, 2000).

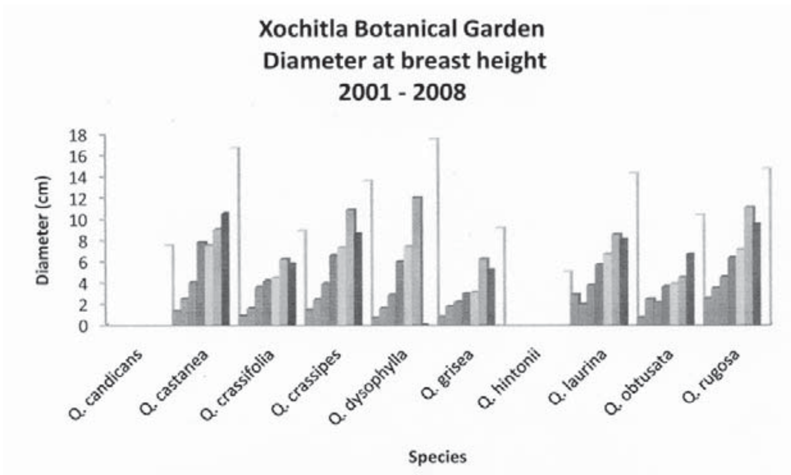
Forestry and phenology. A 2005 forestry and phenological study of the 11 *Quercus* species found that the period of growth occurs between May and September, while seed setting takes place between July and September. However, although it is often believed that only 30- to 40-year-old trees produce acorns, the Xochitla trees are between 7 and 12 years old and germination tests on the acorns found 100% emergence. This contradicts other research, which has found that the acorns of young trees have little or no viability (Garay, *et al*. 2005).

Plant health. If the planted trees are to be properly understood, they have to be studied. This is done by taking an annual inventory, which allows us to make a practical and effective diagnosis of the trees' condition, such as pathological, physiological, or entomological problems affecting the vegetation. This is then used as the basis for establishing the precedence of emergencies, treatment, and future development (Rodríguez, 2001).

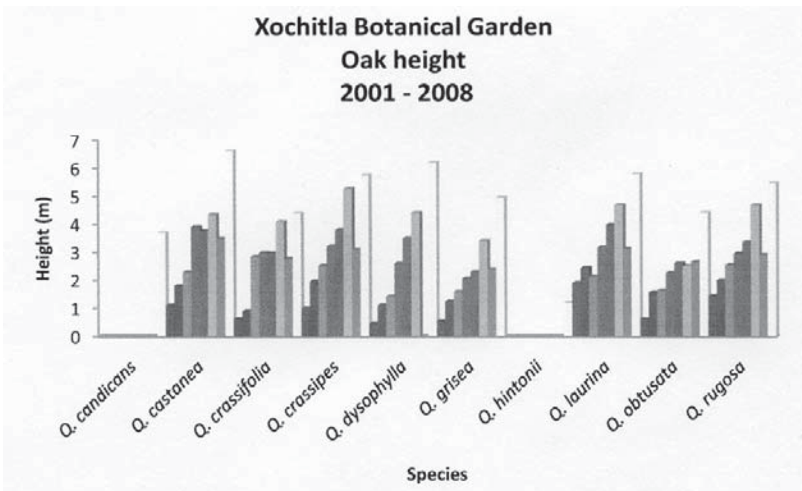
Each evaluation of the *arboretum* has several purposes: to estimate the survival of each species according to the year of planting; to take an annual census of the height and diameter of each tree in order to calculate development and growth parameters; to make an annual diagnosis of the health of the trees by evaluating the physical condition and health of the foliage and trunk; and to identify and propose urgent maintenance actions that will encourage the optimum development and growth of the trees (management plan).

The following are the major findings of our evaluations:

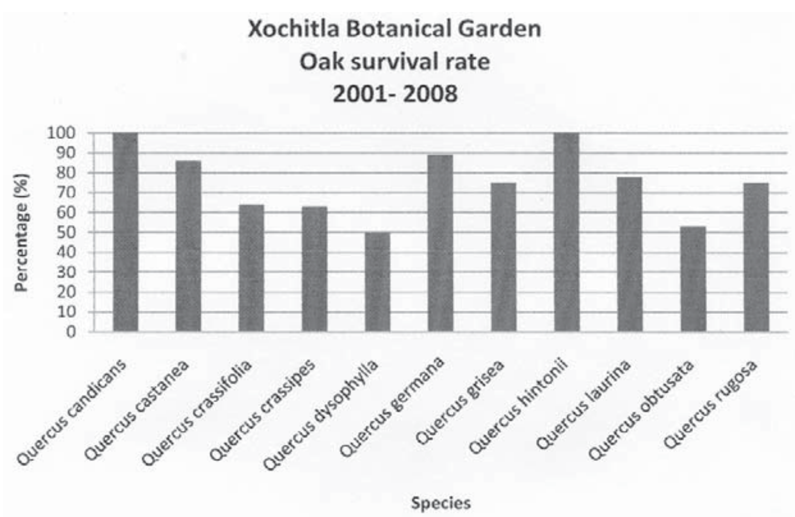
- Tree diameter and height (Graphs 1 and 2) are increasing gradually as a result of good maintenance conditions;
- The survival rate of the trees planted between 1999 and 2008 is between 50*%* **and** 100% (Graph 3). The major factors causing mortality during the early years of development were: a) low temperatures in winter and the fluctuation between minimum and maximum temperatures throughout the day (in winter, lows of minus 14 C and highs of 25 C have been recorded on the same day); b) soil compaction and the scarcity of nutrients; c) coiled roots in all oak species, but especially in *Q*. *rugosa*, as a result of soil conditions.



Graph 1. Diameter at breast height (DBH). *Q. dysophylla* and *Q. castanea* are the species with the greatest increase in trunk thickness.



Graph 2. Oak height. *Q castanea* and *Q. dysophylla* are also the tallest species. The data for *Q. candicans* and *Q. hintonii* apply only to 2008, the year in which they were planted.



Graph 3. While the survival rate for some species is 100%, in others it is only 50%. Several factors have a bearing on this: a) the number of individual trees planted; b) the year when they were planted; and c) their adaptation to local conditions.

*Horticulture***.** Xochitla's main soil problems, i.e. its compaction and low fertility, have been combated by improving its structure and adding nutrients. Our aggressive decompaction program involves drilling one-meter deep holes into the soil to aerate it and improve its quality by filling the holes with a mixture of worm compost and expanded perlite. Furthermore, the soil's fertility has been improved by adding organic material in the form of green fertilizers (temperate leguminous plants such as V*icia sativa* and *Brassica napus*). Mulch is put on top of the soil around the trees to help conserve moisture.

Fig. 2. *Q. frutex* in a flexible container that provides the roots with the space they need as the tree grows.

The main pests found have been phytophagous insects. Diseases include cankers and rusts. In general, both pests and diseases are being kept under control with regular supervision and the implementation of cultivation management which includes frequent watering, fertilization, and weeding. To obtain good quality plants, great attention is paid to the early stages of their development: root formation is monitored to prevent coiling, regular fertilization routines are followed, and different-size containers are used to suit the growth stages of individual trees. For a few years after the trees have been planted, they are shaped by pruning.

Training, education, and management: The research carried out as part of the oak project has provided biology students on social service or work experience programs with an opportunity to receive training with the support from researchers from academic institutions such as the National Autonomous University of Mexico. Some 10,000 students drawn from various educational levels have learned about the practice and importance of oak conservation on Xochitla's environmental education courses. We have also been able to influence plant production and reforestation plans at the Sierra de Tepotzotlán State Park, where we have persuaded regional authorities to reforest with oak trees instead of eucalyptus.

Fig. 3. Shaping a tree by pruning.

Conclusions

As well as playing an important role in increasing our knowledge of the propagation and phenology of the genus and allowing us to learn more about the cultivation of oak trees, the establishment of the Xochitla Botanical Garden arboretum, with its *Quercus* trees, has given us the opportunity to let the people of a city as big as Mexico City learn about their importance.

There have been many challenges, because the Xochitla oaks are growing in unfavorable soil conditions, and greater scientific and technical knowledge is required if their long-term survival is to be ensured. Nevertheless, we consider it vital to carry out further research of the sort that we have been doing so far, because the way in which the *Quercus* develops, as well as its behavior, shade and beauty, give it great potential for use as an urban tree in Mexico's temperate regions. Indeed, its use could reduce the enormous shortage of green areas in Greater Mexico City. We are extremely interested in creating alliances with Mexican and international academic institutions, as well as with donors, to strengthen the lines of research that we have described.

We plan to build up a regional collection of oaks (from Mexico City and Mexico State) by collecting parental material from natural habitats and setting up plant production and development programs. We are also seeking exchange and donation agreements with other botanical gardens or similar organizations to strengthen the networks for the *ex situ* conservation of species of environmental, social, and economic importance to Mexico. We consider, too, that there is enormous potential in the medium term for entities like the Sierra de Tepotzotlán State Park (whose original vegetation consisted mainly of oaks) to use the knowledge we have gained. This would be in line with the Global and Mexican Strategies for Plant Conservation, which call for sustainable use and the fair distribution of plant resources by means of *in situ* conservation.

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Quercus germana. photo©Guy Sternberg

Oak Woods of Puebla

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Oak forests were highly respected in ancient times. The forest was, for ancient Mexicans, a place of wind, cold, fear and tears, where wild beasts, snakes and tarantulas lived. It was said that everything can get in but nothing can get out. There were big trees whose wood was used in the construction of houses, furniture and instruments, but man had to go into it only protected with a stone axe.

The Ahuatl or oak was considered as a shade tree and good for lumber. Another oak was known as the Teocuathuitl, the "divine or old tree", perhaps because the "huictlis" were made with this kind of wood to plant the divine corn. The Huictli was the most important tool for indigenous cultures because it was used in all stages of corn cultivation, as well as a planting stick with its fire-hardened tip, it served as a shovel, hoe and dustpan (Aguilera, 1985).

Upon arrival, the *conquistadores* brought ancient knowledge about European oaks. They had perfected the production of various high quality wood products used for construction. The American oaks represented a big challenge for them because they showed dense, hard and very resistant wood. Many oaks ended their long life as beams, wagon wheels, railway sleepers, constructions, firewood, coal and various other products. Another important factor in the loss of forests was the founding of cities in temperate zones, such as Mexico, Veracruz and Puebla. These cities were built where the weather is mild and there were large tracts of pine-oak forest.

What happened to the oak woods in Puebla? Puebla is ranked fifth place in oak diversity in Mexico with 50 species. In pre-hispanic times the impact was not very drastic but later, with the arrival of the Spaniards, the destruction increased up to the point of leaving the great plains without trees and unable to recover. It has recently been estimated that there are 325.5 square kilometers of oak woods in Puebla state, 90% less than in 1981 when 3,390 square kilometers were registered (Benitez 2009).

This essay examines some cases of the loss of the oak woods to urban areas, excessive exploitation and because of ignorance of the ecological value of oaks.

La Calera, or the Villa Galaxy residential area, is one of the last oak forests in Puebla city whose existence is threatened by housing projects in the urban zone. Also Flor del Bosque park and the Amozoc mountains are some of the last oak forests in the city of Puebla. (Mejía, 2009)

It was possible to exploit this forest legally, as according to environmental impact studies the area is categorized with low biodiversity (Tajonar, 2009). However, according to surveys in La Calera forest, there are 7 oak species (6 trees and 1 shrub): *Quercus sebifera* Trel., *Quercus mexicana* Bonpl., *Quercus acutifolia* Née, *Quercus liebmannii* Oerst. ex Trel., *Quercus laeta* Liebm., *Quercus* *obtusata* Bonpl.*,* *Quercus castanea* Née. Another study found 75 species of birds in this forest of which 3 species are subject to special protection, according to NOM-059-SEMARNAT-2001. These are the migratory Cooper´s hawk (*Accipiter cooperii*) and the native Pileated flycatcher (*Xenotriccus mexicanus*) and Brown-backed solitaire (*Myadestes occidentalis*).

There are other species present, that although not listed in the Official Mexican Standard are very significant - *Melanerpes formicivorus* (Acorn woodpecker) Resident; *Picoides scalaris* (Ladder-backed woodpecker) Resident; *Campylorhynchus jocosus* (Boucard's wren) Resident; *Thryomanes bewickii* (Bewick's wren) Resident (Pineda, Mendoza and Jimenez, 2009)**.**

Another case is the Valsequillo Valley, a dry valley adjacent to La Calera and part of the Tenzo mountain range. This valley contains the Manuel Avila Camacho dam built in 1940. The valley was once surrounded by oak woods but the building of the dam saw the beginning of their destruction, now reduced to a few small populations.

In this area there are at least 12 oak species (2 shrubs and 10 trees) which are currently isolated patches in large areas. *Quercus acutifolia, Q. mexicana, Q. castanea, Q. glaucoides* M. Martens & Galeotti*, Q. glabrescens* Benth.*, Q. liebmannii, Q. magnoliifolia* Née*, Q. obtusata, Q. laeta, Q. microphylla* Née*, Q. sebifera, Q. grahamii* Benth.. There are 12 orchid species (1 epiphyte and 14 terrestrial), 9 bromeliad species (7 *Tillandsia* spp. and 2 *Hechtia* spp.), 8 Agavaceae (1 *Polianthes*, 2 *Manfreda*, 2 *Yucca*, 4 *Agave*) and several native species of small mammals including *Bassariscus astutus,* (civet or Ring-tailed cat), *Mustela* sp. (weasel) and the opossum.

Several other important areas are being affected by the subdivision of

Q. glaucoides by the resevoir at Valsequillo.

land. The construction of the Captain Carlos Camacho Espiritu Boulevard was proposed 5 years ago. A two-lane highway became four and brought with it the sale of land without a land-use study. The same site contains several examples of hundred-year-old trees, such as the Ahuacoxtle (*Quercus glaucoides*), which is estimated at 300 years old (Photo 1) and a Chavarro (*Quercus laeta*), which may be in danger of ending its days as fuel (Files Botanical Garden "Louise Wardle de Camacho").

Another affected area is La Malinche (belonging both to Puebla and Tlaxcala), where oak and pine forests covered the mountains. These forests have been degraded by 90% on the Puebla side of the mountain. This year it was estimated that about 1800 hectares of the 2000 that belong to the municipality have been totally cleared. Illegal logging has been the most acute problem in this area, and although there have been many reforestation projects there is little seedling survival due to underground fires made by the loggers. It is estimated that at least 200 hectares are lost per year. This area is very important because La Malinche is considered a source of water for Puebla City (Newspaper Milenio-Puebla, 2009).

The final example is the locality called Puerto del Aire, adjacent to Veracruz state. In this part of the state of Puebla, it is not possible to estimate the future of oaks. There are two types, the actual oak forest and oak-pine forest and a xeric shrubland dominated by *Quercus sebifera* (a shrub) and *Quercus greggii* (A.DC.) Trel. (a shrub or tree). There are 3 species of *Sedum* and one *Echeveria*, legumes, agaves and even epiphytic orchids. The oaks here form a complex of very dense thickets. These landscapes are being threatened by pine plantations and cattle grazing, so it is almost impossible to find recent shoots or seedlings and most are mature trees.

There are several strategies, all them with a common goal, to spread the importance and appreciation of oaks and the vital role they play within ecosystems. Actions are being taken to defend the last remaining relics of oak woodland in the city of Puebla, such as a project by the State Ecology Council to expand the zone of the Tehuacan-Cuicatlán biosphere to include Puerto del Aire. Two important *ex situ* oak collections exist in Puebla, the Botanical Garden of the Benemerita University of Puebla and the Louise Wardle Camacho Botanical Garden.

It is clear that competition for space and population growth is affecting these species, however different organizations, both governmental and non-governmental, are giving a major boost to oak conservation to avoid their extinction from the areas formerly occupied.

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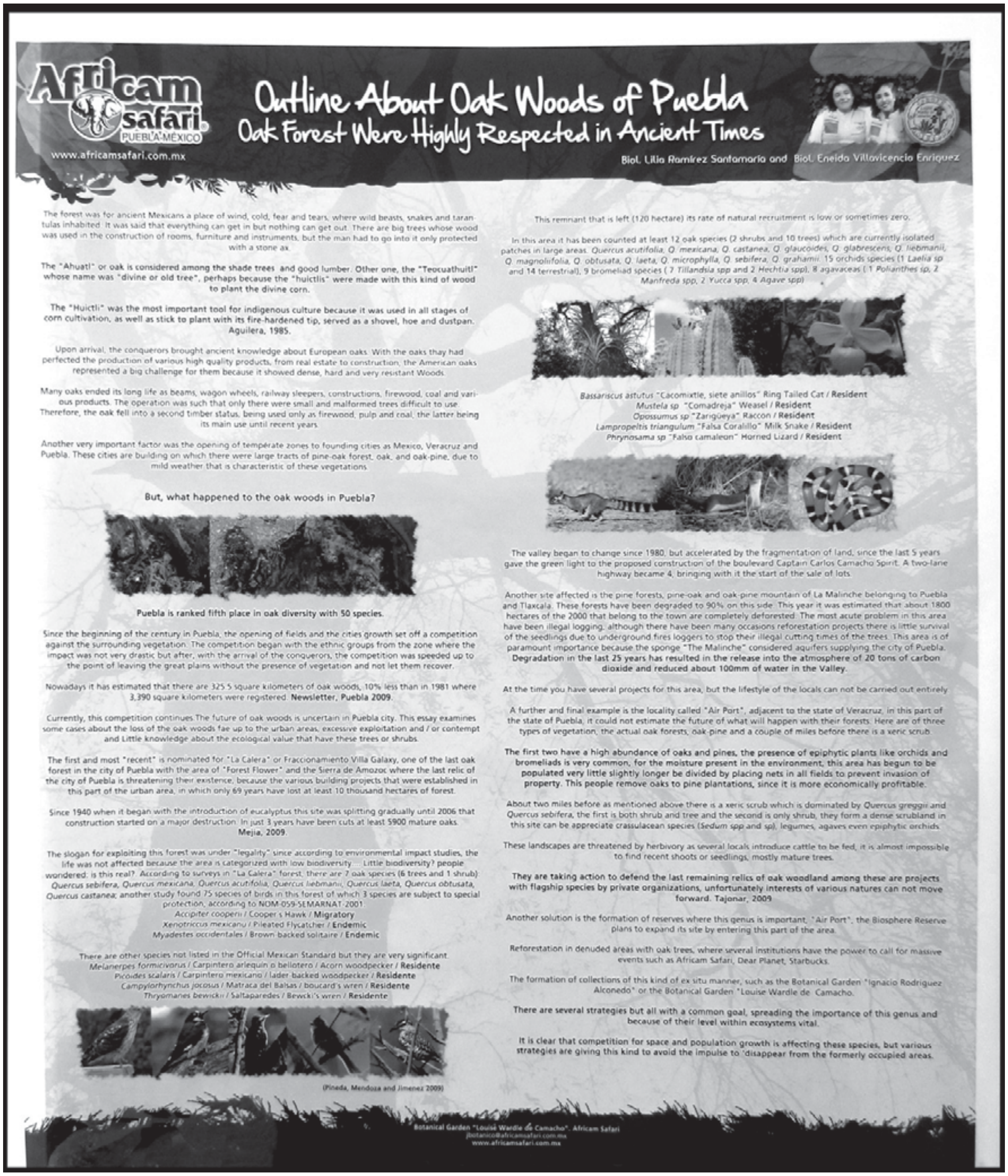

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The Oaks of the Mexican Bajío

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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 inumerable 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 km^2 (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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Facultad de Estudios Superiores Iztacala-UNAM
Especies del Bajío Mexicano
Arquitectura foliar
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 34 son endémicas de México y 11 habitan en Guatemala, Centroamérica y/o EUA. Se consideran 23 especies como muy escasas en el Bajío.
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 xerófilo (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* Schltdl. & 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* Schltdl. & 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* Schltdl. & 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.

Thanks to Béatrice Chassé for translation and Allen Coombes for assistance with review.

The Distribution of Oaks (*Quercus*) in Mexico and Neighbouring Countries

A Consultative Document Produced For Participants of The 6th International Oak Conference, Puebla, October 2009

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Introduction

This short document aims to express all the accepted names of oaks within Mexico, together with their natural distribution by state. Where these taxa are indigenous to nearby countries, the wider distribution is also indicated. A few names in this listing represent questionable taxa for which further information is required.

Distribution is given by country and state running roughly from North to South and from West to East.

The distribution data was derived from a report generated from the Oak Names website which was originally compiled from three main published works:

1. Rafaël Govaerts & David Frodin, World Checklist and Bibliography of Fagales. Royal Botanic Gardens, Kew. (1998)
   Revisions kept online at: http://apps.kew.org/wcsp/advanced.do

2. Susana Valencia-Avalos: **Diversidad del Género *Quercus* (Fagaceae) en México**. *Boletín de la Sociedad Botánica de México* 75: 33-53 (2004)
   Available online at: http://redalyc.uaemex.mx/redalyc/pdf/577/57707503.pdf

3. Silvia Romero-Rangel: **Revisión Taxonómica del Complejo Actuifoliae de *Quercus* (Fagaceae) con Énfasis en su Representación en México**. *Acta Botanica Mexicana* 76: 1-45 (2006).
   Available on-line at: http://redalyc.uaemex.mx/src/inicio/ArtPdfRed.jsp?iCve=57407601

It is hoped that this document will be stimulating and useful to those on field trips and as a background to the conference proceedings. The compiler will be particularly interested to hear of any omissions, errors, and other corrections, so that the data on the website might be continually revised and updated in the light of further knowledge and understanding.

Further information may be obtained through the search pages of the on-line version of the Oak Names Checklist available at: **http://www.oaknames.org**

Please send or give any feedback to the author.

Quercus acherdophylla Trel. (1924) MEXICO: (Hidalgo, Veracruz, Puebla)
Quercus aculcingensis Trel. (1922) MEXICO: (Veracruz)
Quercus acutangula Trel. (1934) *stat. dub*. MEXICO: (Guerrero)
Quercus acutifolia Née (1801) MEXICO: (Jalisco, Michoacán, México State, Puebla. Guerrero, Oaxaca, Chiapas), BELIZE, GUATEMALA, HONDURAS
Quercus aerea Trel. (1924) MEXICO: (Chihuahua, San Luis Potosí)
Quercus affinis Scheidw. (1837) MEXICO: (Nuevo León, Tamaulipas, San Luis Potosí, Guanajuato, Querétaro, Hidalgo, Veracruz, Puebla, Guerrero, Oaxaca)
Quercus agrifolia Née (1801) USA: (W & S California), MEXICO: (Baja California del Norte)
Quercus ajoensis C. H. Mull. (1954) USA: (Arizona), MEXICO: (Baja California del Norte)
Quercus albocincta Trel. (1924) MEXICO: (Sonora, Chihuahua, Sinaloa, Durango)
Quercus alpescens Trel. (1924) MEXICO: (Nuevo León, Hidalgo)
Quercus aristata Hook. & Arn. (1841) MEXICO: (Sinaloa, Nayarit, Jalisco, Aquascalientes)
Quercus arizonica Sarg. (1895) USA: (Arizona, New Mexico, W Texas), MEXICO: (Sonora, Chihuahua, Coahuila, Durango)
Quercus ×basaseachicensis C. H. Mull. (1938) MEXICO: (Chihuahua, Durango)
Quercus benthamii A. DC. (1864) MEXICO: (Guerrero, Chiapas), GUATEMALA, EL SALVADOR, NICARAGUA, COSTA RICA, PANAMA
Quercus berberidifolia Liebm. (1854) USA: (California), MEXICO: (Baja California del Norte)
Quercus brandegeei Goldman (1916) MEXICO: (Baja California do Sul)
Quercus brenesii Trel. (1924) MEXICO: (Veracruz), NICARAGUA, COSTA RICA
Quercus canbyi Trel. (1924) USA: (Texas), MEXICO: (Coahuila, Neuvo León, Tamaulipas)
Quercus candicans Née (1801) MEXICO: (Chihuahua, Sinaloa, Durango, Nayarit, Jalisco, Hidalgo, Veracruz, Michoacán, México State, México DF, Morelos, Puebla, Guerrero, Oaxaca, Chiapas), GUATEMALA
Quercus carmenensis C. H. Mull. (1937) USA: (SW Texas), MEXICO: (Coahuila)
Quercus castanea Née (1801) MEXICO: (Sonora, Sinaloa, Durango, San Luis Potosí, Nayarit, Jalisco, Guanajuato, Hidalgo, Veracruz, Colima, Michoacán, México State, México DF, Morelos, Puebla, Guerrero, Oaxaca,

Chiapas), GUATEMALA, EL SALVADOR

Quercus cedrosensis C. H. Mull. (1962) MEXICO: (Baja California del Norte: Cedros Island)

Quercus charcasana Trel. ex A. Camus (1952) *stat. dub*. MEXICO: (San Luis Potosí)

Quercus chartacea Trel. (1924) *stat. dub*. MEXICO: (Oaxaca, Chiapas)

Quercus chrysolepis Liebm. (1854) USA: (Arizona, California, S Nevada, New MEXICO, W Oregon), MEXICO: (Baja California del Norte, NW Chihuahua)

Quercus coahuilensis Nixon & C. H. Mull. (1993) MEXICO: (Chihuahua, Coahuila)

Quercus coffeicolor Trel. (1924) MEXICO: (Sinaloa, Nayarit, Jalisco)

Quercus conspersa Benth. (1842) MEXICO: (Jalisco, Michoacán, México State, Guerrero, Oaxaca, Chiapas), GUATEMALA

Quercus convallata Trel. (1924) MEXICO: (Durango, Zacatecas, Nayarit, Jalisco)

Quercus conzattii Trel. (1921) MEXICO: (Durango, Zacatecas, Nayarit, Jalisco, Oaxaca)

Quercus cornelius-mulleri Nixon & K. P. Steele (1981) USA: (California), MEXICO: (Baja California del Norte)

Quercus corrugata Hook. (1842) MEXICO: (Puebla, Guerrero, Oaxaca, Chiapas, Veracruz), BELIZE, GUATEMALA, EL SALVADOR, HONDURAS, COSTA RICA, PANAMA

Quercus cortesii Liebm. (1854) MEXICO: (Puebla, Chiapas), BELIZE, HONDURAS, NICARAGUA, COSTA RICA, PANAMA

Quercus crassifolia Bonpl. (1809) MEXICO: (Chihuahua, Durango, Zacatecas, San Luis Potosí, Jalisco, Guanajuato, Querétaro, Hidalgo, Veracruz, Michoacán, México State, México DF, Tlaxcala, Puebla, Guerrero, Oaxaca, Chiapas), GUATEMALA

Quercus crassipes Bonpl. (1809) MEXICO: (Jalisco, Guanajuato, Querétaro, Hidalgo, Colima, Michoacán, México State, México DF, Morelos, Tlaxcala, Puebla, Oaxaca)

Quercus crispifolia Trel. (1924) MEXICO: (Guerrero, Oaxaca, Chiapas), GUATEMALA ?, COLOMBIA ?

Quercus crispipilis Trel. (1924) MEXICO: (Chiapas), GUATEMALA

Quercus cualensis L. M. González (2003) MEXICO: (Jalisco)

Quercus deliquescens C. H. Mull. (1979) MEXICO: (Chihuahua)

Quercus depressa Bonpl. (1809) MEXICO: (Hidalgo, Veracruz, Puebla, Oaxaca)

Quercus depressipes Trel. (1924) USA: (W Texas), MEXICO: (Chihuahua, Durango, S Zacatecas, N Jalisco)

Quercus deserticola Trel. (1924) MEXICO: (Querétaro)

Quercus devia Goldman (1916) MEXICO: (Baja California do Sul: Sierra de la Laguna, Cape Reg.)

Quercus diversifolia Née (1801) MEXICO: (México State, México DF, Puebla)

Quercus dumosa Nutt. (1842) USA: (California), MEXICO: (Baja California del Norte)

Quercus durandii Buckley (1861) USA: (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Texas), MEXICO: (Coahuila, Nuevo León, Tamaulipas)

Quercus duratifolia C. H. Mull. (1942) MEXICO: (Chiapas)

Quercus durifolia Seemen ex Loes. (1900) MEXICO: (Sonora, Chihuahua, Sinaloa, Durango)

Quercus ×dysophylla Benth. (1840) MEXICO: (Guanajuato, Hidalgo, Veracruz, Michoacán, México State, México DF, Tlaxcala)

Quercus eduardii Trel. (1922) MEXICO: (Chihuahua, Tamaulipas, Durango, Zacatecas, San Luis Potosí, Nayarit, Jalisco, Aquascalientes, Guanajuato, Querétaro, Hidalgo, Veracruz, Michoacán)

Quercus edwardsiae C. H. Mull. (1942) MEXICO: (Nuevo León)

Quercus elliptica Née (1801) MEXICO: (Sinaloa, Nayarit, Jalisco, Varacruz, Michoacán, México State, Guerrero, Oaxaca, Chiapas), BELIZE, GUATEMALA, EL SALVADOR, HONDURAS, NICARAGUA

Quercus emoryi Torr. (1848) USA: (Arizona, New Mexico, W Texas), MEXICO: (Sonora, Chihuahua, Coahuila, Nuevo León, Tamaulipas, Durango)

Quercus engelmannii Greene (1889) USA: (S California), MEXICO: (Baja California del Norte)

Quercus eugeniifolia Liebm. (1854) MEXICO: (Oaxaca, Puebla, Hidalgo, Veracruz), GUATEMALA, EL SALVADOR, COSTA RICA, PANAMA

Quercus* aff. *eugeniifolia MEXICO: (Hidalgo)

Quercus floccosa Liebm. (1854) *stat. dub.* MEXICO: (Veracruz)

Quercus flocculenta C. H. Mull. (1936) MEXICO: (Nuevo León)

Quercus frutex Trel. (1924) MEXICO: (Hidalgo, Michoacán, México State, México DF, Tlaxcala, Puebla, Oaxaca)

Quercus fulva Liebm. (1854) MEXICO: (Chihuahua, Sinaloa, Durango, Nayarit, Jalisco)

Quercus furfuracea Liebm. (1854) MEXICO: (San Luis Potosí, Puebla)

Quercus fusiformis Small (1903) USA: (SW Oklahoma, Texas), MEXICO: (Coahuila, Nuevo León, Tamaulipas)

Quercus galeanensis C. H. Mull. (1936) MEXICO: (Nuevo León)

Quercus galeottii M. Martens & Galeotti (1843) MEXICO: (Veracruz)

Quercus gambelii Nutt. (1847) USA: (Arizona, Colorado, Nevada, New Mexico, Oklahoma, Texas. Utah, Wyoming), MEXICO: (Sonora, Chihuahua, Coahuila)

Quercus gentryi C. H. Mull. (1942) MEXICO: (Chihuahua, Sinaloa, Zacatecas, Nayarit, Jalisco, Michoacán)

Quercus germana Schltdl. & Cham. (1830) MEXICO: (Tamaulipas, San Luis Potosí, Veracruz, Hidalgo, Puebla, Oaxaca)

Quercus ghiesbreghtii M. Martens & Galeotti (1843) *stat. dub.* MEXICO: (Veracruz)

Quercus glabrescens Benth. (1840) MEXICO: (San Luis Potosí, Hidalgo, Veracruz, Michoacán, México State, México DF, Tlaxcala, Puebla, Oaxaca)

Quercus glaucescens Bonpl. (1809) MEXICO: (Sinaloa, Nayarit, Jalisco, Veracruz, Michoacán, Guerrero, Oaxaca)
Quercus glaucoides M. Martens & Galeotti (1843) MEXICO: (Sinaloa, Zacatecas, San Luis Potosí, Nayarit, Jalisco, Guanajuato, Hidalgo, Michoacán, México State, Morelos, Puebla, Guerrero, Oaxaca)
Quercus gravesii Sudw. (1927) USA: (SW Texas), MEXICO: (Coahuila)
Quercus greggii (A. DC.) Trel. (1922) MEXICO: (Coahuila, Nuevo León, Tamaulipas. Durango, San Luis Potosí, Nayarit, Hidalgo, Veracruz, Puebla, Oaxaca)
Quercus grisea Liebm. (1854) USA: (Arizona, New Mexico, W Texas), MEXICO: (Sonora, Chihuahua, Coahuila, Nuevo León, Durango, Zacatecas, San Luis Potosí, Jalisco, Aquascalientes, Guanajuato, Veracruz)
Quercus hinckleyi C. H. Mull. (1951) USA: (Texas: Presidio County), MEXICO: (Sonora, N Chihuahua)
Quercus hintonii E. F. Warb. (1939) MEXICO: (Michoacán, México State)
Quercus hintoniorum Nixon & C. H. Mull. (1993) MEXICO: (Coahuila)
Quercus hirtifolia M. L. Vázquez *et al*. (2004) MEXICO: (Hidalgo, Puebla)
Quercus hypoleucoides A. Camus (1932) USA: (Arizona, SW New Mexico, W Texas), MEXICO: (Sonora, Chihuahua, Coahuila, Nuevo León, Durango)
Quercus hypoxantha Trel. (1924) MEXICO: (Coahuila, Nuevo León, San Luis Potosí)
Quercus ignaciensis C. H. Mull. (1942) MEXICO: (Sonora)
Quercus iltisii L. M.González (2003) MEXICO: (Jalisco, Colima)
Quercus insignis M. Martens & Galeotti (1843) MEXICO: (Veracruz, Oaxaca, Chiapas), BELIZE, GUATEMALA, HONDURAS, NICARAGUA, COSTA RICA, PANAMA:
Quercus intricata Trel. (1922) USA: (W Texas), MEXICO: (Chihuahua, Coahuila, Nuevo León, Durango, Zacatecas)
Quercus invaginata Trel. (1924) MEXICO: (Chihuahua, Coahuila, Nuevo León)
Quercus jonesii Trel. (1924) MEXICO: (Sonora, Chihuahua, San Luis Potosí, Nayarit, Jalisco)
Quercus juergensenii Liebm. (1854) *stat. dub.* MEXICO: (Puebla)
Quercus ×knoblochii C. H. Mull. (1942) *stat. dub.* MEXICO: (Chihuahua, Sonora)
Quercus laceyi Small (1901) USA: (Texas), MEXICO: (Coahuila, Nuevo León)
Quercus laeta Liebm. (1854) MEXICO: (Coahuila, Nuevo León, Sinaloa, Durango, Zacatecas, San Luis Potosí, Nayarit, Jalisco, Aquascalientes, Guanajuato, Hidalgo, Michoacán, México State, México DF, Oaxaca)
Quercus laurina Bonpl. (1809) MEXICO: (Jalisco, Guanajuato, Querétaro, Hidalgo, Veracruz, Michoacán, México State, México DF, Morelos, Tlaxcala, Puebla, Guerrero, Oaxaca), GUATEMALA
Quercus laxa Liebm. (1854) MEXICO: (Sinaloa, Nayarit, Jalisco, Colima, Michoacán)
Quercus leiophylla A. DC. (1864) MEXICO: (Hidalgo, Veracruz, Puebla, Oaxaca)

Quercus liebmannii Oerst. ex Trel. (1924) MEXICO: (Puebla, Guerrero, Oaxaca)

Quercus macdougallii M. Martínez (1964) MEXICO: (Oaxaca)

Quercus macvaughii Spellenb. (1992) MEXICO: (Sonora, Chihuahua, Durango)

Quercus magnoliifolia Née (1801) MEXICO: (Sinaloa, Nayarit, Jalisco, Hidalgo, Colima, Michoacán, México State, Morelos, Puebla, Guerrero, Oaxaca)

Quercus manzanillana Trel. (1924) *stat. dub.* MEXICO: (Puebla)

Quercus martinezii C. H. Mull. (1954) MEXICO: (Nayarit, Jalisco, Michoacán, México State, Guerrero, Oaxaca)

Quercus mexicana Bonpl. (1809) MEXICO: (Chihuahua, Nuevo León, Tamaulipas, San Luis Potosí, Querétaro, Hidalgo, Veracruz, México State, México DF, Tlaxcala, Puebla)

Quercus microphylla Née (1801) MEXICO: (Coahuila, Nuevo León, Tamaulipas, San Luis Potosí, Nayarit, Jalisco, Aquascalientes, Guanajuato, Querétaro, Hidalgo, Veracruz, Puebla, Oaxaca)

Quercus miquihuanensis Nixon & C.H. Mull. (1993) MEXICO: (Nuevo León, Tamaulipas)

Quercus mohriana Buckley ex Rydb. (1901) USA: (NE New Mexico, W Oklahoma, WC & W Texas), MEXICO: (Coahuila)

Quercus muehlenbergii Engelm. (1877) CANADA: (S Ontario), USA: (Alabama, Arkansas, Connecticut, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Lousiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas,Vermont, Virginia, West Virginia, Wisconsin), MEXICO: (Coahuila, Nuevo León, Tamaulipas, Veracruz),

Quercus mulleri M. Martínez (1953) MEXICO: (Oaxaca)

Quercus nixoniana S. Valencia & Lozada-Pérez (2003) MEXICO: (Jalisco, Guerrero, Oaxaca)

Quercus oblongifolia Torr. (1853) USA: (Arizona, SW New Mexico, W Texas), MEXICO: (Sonora, Chihuahua, Coahuila, Durango)

Quercus obtusanthera Trel. (1934) *stat. dub.* MEXICO: (Guerrero)

Quercus obtusata Bonpl. (1809) MEXICO: (Nuevo León, Durango, Zacatecas, San Luis Potosí, Nayarit, Jalisco, Guanajuato, Querétaro, Hidalgo, Veracruz, Michoacán, México State, México DF, Morelos, Puebla, Guerrero, Oaxaca)

Quercus oleoides Schltdl. & Cham. (1830) MEXICO: (Tamaulipas, San Luis Potosí, Hidalgo, Veracruz, Puebla, Oaxaca, Chiapas, Tabasco, Campeche, Yucatán), CUBA, BELIZE, GUATEMALA, HONDURAS, NICARAGUA, COSTA RICA

Quercus oleoides Schltdl. & Cham. subsp. ***oleoides*** MEXICO: (Puebla, Oaxaca, Chiapas, Tabasco, Campeche, Yucatán), BELIZE, GUATEMALA, HONDURAS, COSTA RICA

Quercus oocarpa Liebm. (1854) MEXICO: (Nayarit, Jalisco, Guerrero, Chiapas), BELIZE ?, GUATEMALA, EL SALVADOR, HONDURAS,

NICARAGUA, COSTA RICA, PANAMA
Quercus opaca Trel. (1924) MEXICO: (Tamaulipas, Hidalgo, México State, Oaxaca)
Quercus ×pachucana Zavala-Chávez (2000) *pro sp*. MEXICO: (Hidalgo)
Quercus palmeri Engelm. (1877) USA: (Arizona, S California), MEXICO: (Baja California del Norte)
Quercus ×pastorensis C. H. Mull. (1936) MEXICO: (Nuevo León)
Quercus peduncularis Née (1801) MEXICO: (Nayarit, Jalisco, Veracruz, Colima, Michoacán, México State, Puebla, Guerrero, Oaxaca, Chiapas), BELIZE ?, GUATEMALA, HONDURAS
Quercus peninsularis Trel. (1924) MEXICO: (Baja California del Norte)
Quercus perpallida Trel. (1924) MEXICO: (Baja California del Norte, Sonora, Chihuahua)
Quercus pinnativenulosa C. H. Mull. (1936) MEXICO: (Nuevo León, Tamaulipas, San Luis Potosí, Querétaro, Veracruz)
Quercus planipocula Trel. (1924) MEXICO: (Sinaloa, Nayarit, Jalisco, Guerrero, Michoacán)
Quercus polymorpha Schltdl. & Cham. (1830) USA: (S Texas), MEXICO: (Nuevo León, Tamaulipas, San Luis Potosí, Hidalgo, Veracruz, Puebla, Oaxaca, Chiapas), GUATEMALa
Quercus potosina Trel. (1924) MEXICO: (Chihuahua, Durango, Zacatecas, San Luis Potosí, Jalisco, Aguascalientes, Guanajuato)
Quercus praeco Trel. (1924) MEXICO: (Zacatecas, Nayarit, Jalisco)
Quercus pringlei Seemen ex Loes. (1900) MEXICO: (Coahuila, Nuevo León, Zacatecas)
Quercus pungens Liebm. (1854) USA: (Arizona, New Mexico, Texas), MEXICO: (Chihuahua, Coahuila)
Quercus purulhana Trel. (1924) MEXICO: (Chiapas), BELIZE, GUATEMALA, HONDURAS, NICARAGUA
Quercus radiata Trel. (1921) MEXICO: (Durango, Zacatecas, Nayarit)
Quercus rekonis Trel. (1924) *stat*. *dub*. MEXICO: (Oaxaca)
Quercus repanda Bonpl. (1809) MEXICO: (Hidalgo, Tlaxcala, Puebla)
Quercus resinosa Liebm. (1854) MEXICO: (Durango, Zacatecas, San Luis Potosí, Nayarit, Jalisco, Aquascalientes, Guanajuato, Michoacán)
Quercus rubramenta Trel. (1934) MEXICO: (Guerrero, Oaxaca)
Quercus rugosa Née (1801) USA: (Arizona, New Mexico, Texas), MEXICO: (Sonora, Coahuila, Nuevo León, Durango, Zacatecas, San Luis Potosí, Jalisco, Aquascalientes, Guanajuato, Querétaro, Hidalgo, Veracruz, Colima, Michoacán, México State, México DF, Morelos, Puebla, Guerrero, Oaxaca, Chiapas), GUATEMALA, HONDURAS
Quercus rugosa La Encantada Form MEXICO: (Nuevo León)
Quercus rugosa La Siberica Form MEXICO: (Nuevo León)
Quercus rugosa Pinal de Arnoles Form MEXICO: (Nuevo León)
Quercus runcinatifolia Trel. & C. H. Mull. (1936) MEXICO: (Nuevo León)
Quercus rysophylla Weath. (1910) MEXICO: (Nuevo León, Hidalgo, Veracruz)
Quercus salicifolia Née (1801) MEXICO: (Guerrero, Jalisco, Michoacán), GUATEMALA, EL SALVADOR, HONDURAS

Quercus saltillensis Trel. (1924) MEXICO: (Coahuila, Nuevo León)
Quercus sanchez-colinii M. Martínez (1954) stat. dub. MEXICO: (Where?)
Quercus sapotifolia Liebm. (1854) MEXICO: (Hidalgo, Veracruz, Oaxaca, Chiapas), BELIZE, GUATEMALA, EL SALVADOR, HONDURAS, COSTA RICA, PANAMA
Quercus schultzei Trel. (1934) stat. dub. MEXICO: (Guerrero)
Quercus scytophylla Liebm. (1854) MEXICO: (Nayarit, Jalisco, Michoacán, México State, Puebla, Guerrero, Oaxaca)
Quercus sebifera Trel. (1924) MEXICO: (Nuevo León, Tamaulipas, San Luis Potosí, Hidalgo, Veracruz, Puebla, Oaxaca, Chiapas)
Quercus segoviensis Liebm. (1854) MEXICO: (Chiapas), BELIZE, GUATEMALA, HONDURAS, NICARAGUA
Quercus sideroxyla Bonpl. (1809) MEXICO: (Sonora, Chihuahua, Coahuila, Nuevo León, Tamaulipas, Durango, Zacatecas, San Luis Potosí, Nayarit, Jalisco, Aquascalientes, Guanajuato)
Quercus skinneri Benth. (1841) MEXICO: (Tamaulipas, Veracruz, Oaxaca, Chiapas), GUATEMALA, EL SALVADOR, HONDURAS
Quercus splendens Née (1801) MEXICO: (Nayarit, Jalisco, Michoacán, Guerrero, Oaxaca)
Quercus striatula Trel. (1924) MEXICO: (Chihuahua, Durango, Zacatecas)
Quercus subspathulata Trel. (1924) MEXICO: (Sonora, Chihuahua, Jalisco)
Quercus supranitida C. H. Mull. (1942) stat. dub. MEXICO: (Nuevo León)
Quercus tarahumara Spellenb. *et al*. (1995) MEXICO: (Sonora, Chihuahua, Sinaloa, Durango)
Quercus tardifolia C. H. Mull. (1936) USA: (Texas: Chisos Mts), MEXICO: (Coahuila)
Quercus tinkhamii C. H. Mull. (1942) MEXICO: (Nuevo León, San Luis Potosí)
Quercus toumeyi Sarg. (1895) USA: (SE Arizona, SW New Mexico, W Texas), MEXICO: (Sonora, Chihuahua)
Quercus tuberculata Liebm. (1854) MEXICO: (Baja California del Norte, Sonora, Chihuahua, Sinaloa, Durango, Nayarit, Michoacán)
Quercus tuitensis L. M. González (2003) MEXICO: (Jalisco)
Quercus turbinella Greene (1889) USA: (Arizona, California, Colorado, Nevada, New Mexico, Texas, Utah), MEXICO: (Baja California del Norte, Sonora, Chihuahua)
Quercus undata Trel. (1924) MEXICO: (Durango)
Quercus ×undulata Torr. (1828) USA: (where?), MEXICO: (Chihuahua)
Quercus urbanii Trel. (1921) MEXICO: (Sinaloa, Durango, Nayarit, México State, Guerrero)
Quercus uxoris McVaugh (1972) MEXICO: (Jalisco, Colima, Guerrero, Oaxaca, Chiapas)
Quercus vallicola Trel. (1924) *stat. dub*. MEXICO: (México DF)
Quercus vaseyana Buckley (1883) USA: (Texas), MEXICO: (Chihuahua, Coahuila, Nuevo León)
Quercus verde C. H. Mull. (1936) MEXICO: (Nuevo León)
Quercus vicentensis Trel. (1924) MEXICO: (Chiapas), GUATEMALA, EL

SALVADOR

Quercus viminea Trel. (1924) USA: (S Arizona), MEXICO: (Sonora, W Chihuahua, Sinaloa, Durango, Nayarit, Jalisco, Aquascalientes, Guanajuato)

Quercus wislizeni A. DC. (1864) USA: (California), MEXICO: (Baja California del Norte)

Quercus wislizeni subsp. ***frutescens*** (Engelm.) E. Murray (1983) USA: (s California), MEXICO: (Baja California del Norte)

Quercus wislizeni A. DC. subsp. ***wislizeni*** USA: (California), MEXICO: (Baja California del Norte)

Quercus xalapensis Bonpl. (1809) MEXICO: (Nuevo León, Tamaulipas, San Luis Potosí, Querétaro, Hidalgo, Veracruz, Puebla, Chiapas)

Notes on the Genus *Quercus* in Mexico

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Introduction

The genus *Quercus* is one of the most important groups of woody plants of the Northern Hemisphere (Nixon 1997, 2002). With approximately 500 species in the world and more than 200 in the Americas, it is the most diverse of the members of the Beech family. It is assumed that there are two areas with the greatest specific diversity in this genus: the first and most diverse is Mexico, with an estimated 140-160 species (Nixon 2002; Valenica, 2004); the second is Southeast Asia, with approximately 125 species (Govaerts and Frodin, 1998).

In the context of this meeting on the genus *Quercus* in the world, the present work aims to present some aspects of Mexican oaks, such as their importance, taxonomy, diversity, distribution, and ecology, as well as the current areas of study of this genus, together with a discussion of some selected groups of species.

Historical importance

Mankind has conferred a special importance on the oaks, considering them a symbol of strength and power. In ancient history, the Greeks regarded oaks as the temple of Zeus. In France, it was common knowledge that their King was only capable of governing and making wise decisions when he did it in the shade of a mighty oak which he had near his palace. Soothsayers could only divine the future through the sounds of the leaves moved by the wind. On the other hand, the hardness of oak wood gave popular sayings such as "as strong as an oak" or "he has the head of an alcornoque", the common name of the European native *Quercus suber* L. In Mexico there are stories of the worship of fragments of oak wood or of temples raised for the worship of oaks. Indeed, on the national seal of Mexico, one of the two tree branches which are crossed at the base is that of an oak.

Economic importance

Oaks constitute one of the most economically important groups in the whole world. They are esteemed for the beauty and durability of their wood; in Mexico, however, despite the fact that it is the greatest center of diversity of the genus, they are utilized principally for wood and charcoal, or in some cases as a source for pulp for paper or for the manufacture of tannins.

In some rural communities acorns are used for human consumption or for animal feed. Nevertheless, they may contain a high concentration of tannins or other toxic substances considered to be poisonous such as those of *Quercus chrysolepis* Liebm.; it is therefore necessary to use them with care or to remove the toxic substances through certain preparatory processes in order for them to be consumed.

For the aging of alcoholic beverages it is traditional to use barrels of white oak. At the present time, however, various species of Mexican oak are under consideration as replacements for the barrels, whereby wood chips alone are added to the containers where the beverage is aged.

The economic potential of Mexican oaks highlights the importance of studies of wood anatomy in order to be able to suggest better ways to utilize this resource in Mexico. Recent studies have linked the anatomy of the wood of some oak species with their environment, providing solid bases for adequate management of this resource.

Ecology

The importance of oaks is well known as the dominant element among many types of vegetation and for playing a fundamental role in the equilibrium of ecosystems. Thier habitat ranges from tropical and subtropical regions to temperate and cold climates. Thus it is possible to find oaks in most vegetation types of Mexico, except aquatic and semiaquatic, often dominating the communities in which they appear, an example of which is the oak forest.

The oak forests of Mexico occupy approximately 4.29% of the surface of the country (Challenger 1998). They can grow in climates with scant precipitation, where species of the section *Quercus* (white oaks) dominate because of their greater tolerance of drought stress, for example *Q. magnoliifolia* Née, *Q.glaucoides* M. Martens & Galeotti, and *Q. liebmannii* Oerst., which form oak thickets growing in the center and south of the country, often mixed with deciduous tropical forest or with xerophyllic underbrush. Oak copses can be found in dry situations at elevations of 400-1000 m. Oak groves in these zones are deciduous and generally do not exceed six meters in height.

Other oak groves somewhat less dry than the foregoing can grow at altitudes of 800 to approximately 1500 m. In the mountains of the north of the country, *Quercus laceyi* Small., *Q. gravesii* Sudw., *Q. arizonica* Sarg., and *Q. jonesii* Trel. are well represented, while towards the center of the country they are replaced by *Q. crassipes* Bonpl., *Q. castanea* Née, *Q. furfuracea* Liebm., *Q. conspersa* Benth. and *Q. laeta* Liebm. Trees of these species can be between ten and fifteen meters tall.

Moist oak groves grow for the most part between 1500 and 2500 meters in altitude. In the mountains of eastern Mexico the dominant elements are *Q. acherdophylla* Trel., *Q. corrugata* Hook., *Q. sartorii* Liebm. and *Q. affinis* Scheidw. In the Sierra Madre Occidental can be found representatives of *Q. crassifolia* Bonpl, *Q. rugosa* Née and *Q. candicans* Née among others. In the center and south of Mexico are *Q. rubramenta* Trel., *Q. martinezii* C.H. Mull., *Q. laurina* Bonpl. and *Q. macdougallii* Martínez. These groves are very rich in diversity; the mature trees surpass 18 m in height, even reaching 35 m and are associated with deep soils rich in nutrients. This forest is often mixed with cloud forest, making it difficult to separate the two.

Cloud forest, though a community restricted to less than 1% of southern Mexico, presents a high diversity of oak species; some of these, indicative of and endemic in this type of vegetation are *Q. cortesii* Liebm., *Q. germana* Schltdl. & Cham., *Q. hirtifolia* M.L. Vazquez *et al*., *Q. insignis* M. Martens & Galeotti, *Q. pinnativenulosa* C.H. Mull. and *Q. uxoris* McVaugh among others.

Oaks can be present in pine forests, forming mixed forests with conifers. In the north of the country in the state of Coahuila grow *Q. mexicana* Bonpl., *Q. saltillensis* Trel., *Q. convallata* Trel. and *Q. laeta* Liebm., forming mixed stands of pines and oaks. In the case of *Q. greggii* (A. DC.) Trel. and *Q. hintoniorium* Nixon & C.H. Mull., they can form thickets which are mixed with trees of sacred fir (*Abies religiosa* (Kunth) Schltdl. & Cham.). Toward the center and south of Mexico mixed forest is frequent in which grow *Q. crassifolia* Bonpl., *Q. candicans* Née, *Q. laurina* Bonpl, *Q. urbanii* Trel. and *Q. rugosa* Née. It is interesting that in the communities occurring above 3000 m in the center and east of the country, in the zone at the limit of arboreal vegetation, oaks form thickets of *Q. depressa* Bonpl, and *Q. repanda* Bonpl. mixed with pines.

Q. pringlei Seemen ex Loes., *Q. intricata* Trel., *Q. striatula* Trel., *Q. invaginata* Trel., Q. *sebifera* Trel. and *Q. fusiformis* Small are well represented in some scrublands.

The dominance of oaks in different communities, in addition to the fact that the majority of the individuals of this genus are habitat specific for numerous species of epiphytic plants such as orchids, bromeliads, ferns and mosses, and for animals such as rodents, birds, reptiles, insects and arachnids, as well as a source of direct or indirect nutrition for these organisms, guarantees that cutting or completely removing oaks will have a considerable impact on the communities where they grow.

In addition to conserving their habitat and providing nourishment for other organisms, oaks can form, improve, and retain soil wherever they grow. They can provide edaphic conditions adequate for the establishment of other species of plants in their vicinity. Adding the former to the great diversity of species and the tolerance and plasticity of some of these gives them the potential to be utilized for reforestation wherever soil has been lost through erosion. Little has been done in this field in our country, but research is underway on the propagation and establishment of some species, as well as projects in propagation in nurseries and greenhouses (as for example the one developed at the University of Puebla by Doctor Maricela Rodriguez), including also some species managed commercially by some nurserymen. All of this establishes a foundation for the development of this area which will permit reforestation with native species of wide expanses of our territory.

Taxonomic Position

The genus *Quercus* is in the family *Fagaceae,* in the order Fagales, and in the Fabid group of the Eudicots (APG 2009). In addition, the family includes the genera *Fagus* (situated as the basal clade in the phylogenetic scheme of the family, Manos *et al*., 2001), *Lithocarpus, Notholithocarpus* (recently segregated from *Lithocarpus*, by Manos *et al*. 2008)*, Colombobalanus, Trigonobalanus,*

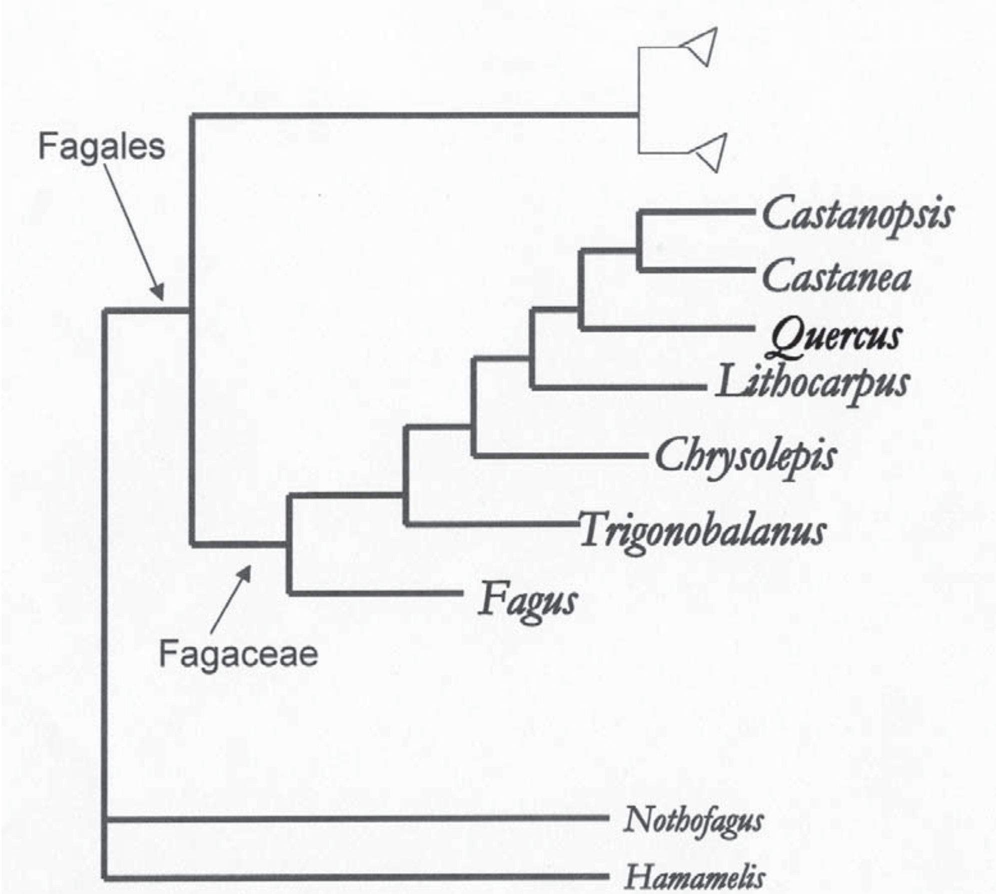

Figure 1. Relationships of *Quercus* and the other genera in Fagaceae (based on Manos *et al*., 2001).

Formanodendron, Chrysolepis, Castanea and *Castanopsis*, the latter two proposed as the most derivative of the family (Manos *et al*.,. 2001) (Figure 1). The family has approximately 900 species in the world (Sang-Hun and Manos 2008).

The genus *Quercus* has been traditionally divided into two subgenera: *Cyclobalanopsis* (distributed in south east Asia) and *Quercus*, with four sections: *Lobatae* (red oaks, America), *Quercus* (white oaks, America, Europe, Asia), *Cerris* (white oaks of the old world) and *Protobalanus* (oaks with a golden cup, western America) (Nixon 1993 and Manos *et al*. 1999). (Figure 2).

In 1924 Trelease proposed the grouping of the species of each section in series. Subsequently Camus (1936-1952) treated them as subsections, but Muller (1942a) showed that these groups lack substance, with the exception of the subsections Virentes, Glaucoideae and Acutifoliae. Subsequent studies (Valencia 1995, 2005) support what Muller demonstrated by showing that the series or subsections reflect neither monophyletic groups nor ancestral relationships among the species which they include, almost all of the groups are artificial and at the present time many no longer exist, since the species from which they were constituted have become synonyms of other species placed in other groups.

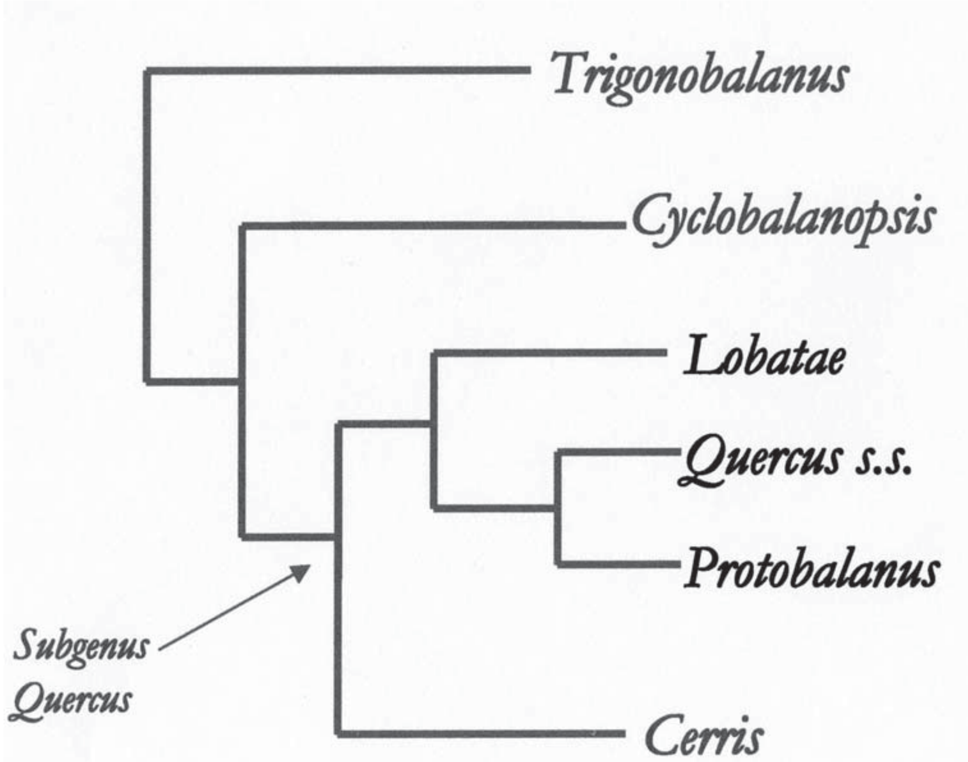

Figure 2. Relationships of subgenera and sections in genus *Quercus* (based on Manos *et al*., 1999).

Most Frequent Problems in the Recognition of Species of the Genus *Quercus*

Any kind of study (biogeographic, evolutionary, phylogenetic, ecological, of diversity or use, among others) regarding the recognition of any group is based on its taxonomy. Nevertheless, the genus *Quercus* is considered a difficult taxonomic group and although there have been substantial advances in the recognition of the Mexican species of the genus, there are still severe problems, above all in certain complexes of species which hybridize and form gradients. Among the most common aspects which lead to taxonomic problems for the species of the genus *Quercus* in Mexico are the following:

High intraspecific morphological variation, even in a single individual, which on occasion can lead to the extreme case of mistakenly identifying a specimen from a tree as one species and another specimen from the same tree as a different species. This obviously reflects the imprecision of specific diversity in the species of this group.

Deficient original descriptions produced in the 19th and first half of the 20th century offer limited information on the variation of the species, with the result that they are insufficient for differentiation of very similar species. The paucity of material for describing new species, the great morphological variation, and the poor understanding of the groups, have led to the interpretation of any variation as indicating a new species, resulting in over description. Subsequent reviews of type specimens, original descriptions, herbarium specimens, and field work, have permitted the recognition and understanding of specific variation and the reduction of many names to the status of synonymy. Thus, for *Q. castanea,* 16 synonyms have been proposed, while for *Q. laurina*, 13 can be cited. Among the most problematic species in this connection are those described by Liebmann (1854) and by Trelease (1924, 1934).

Hybridization between some oak species of the same section is common; this has been observed in the field and amply documented in different bibliographic sources, for different places and between different species. Greater frequency of hybridization has been observed among some species of the section *Quercus* of wide distribution than in the red oaks of narrow distribution. Figures 3 and 4 show some of the most frequent syngameons; some of these are so large and complex that they must be studied intensively in order to understand the comportment of their participants. Hybridization does not only occur between phylogenetically related species; it is sufficient that the species which hybridize be sympatric and have weak barriers to cross breeding.

The resulting hybrids in most cases appear in the field in a sporadic and isolated way among the parents, without forming large masses of hybrid individuals. The hybrids may present a mosaic of intermediate characters, or they may resemble one of the parents more than the other; if introgression is involved, the variation will increase. In these cases the morphological and genetic limits are diluted and taxonomic identification becomes a difficult problem, requiring great care in the observation of the variation in order to adequately identify the species or possible hybrids.

Limited access to the original material. It is estimated that around 160 species of oaks occur in Mexico, but around 800 names and descriptions are associated with them, many times of doubtful form. The cleansing of the

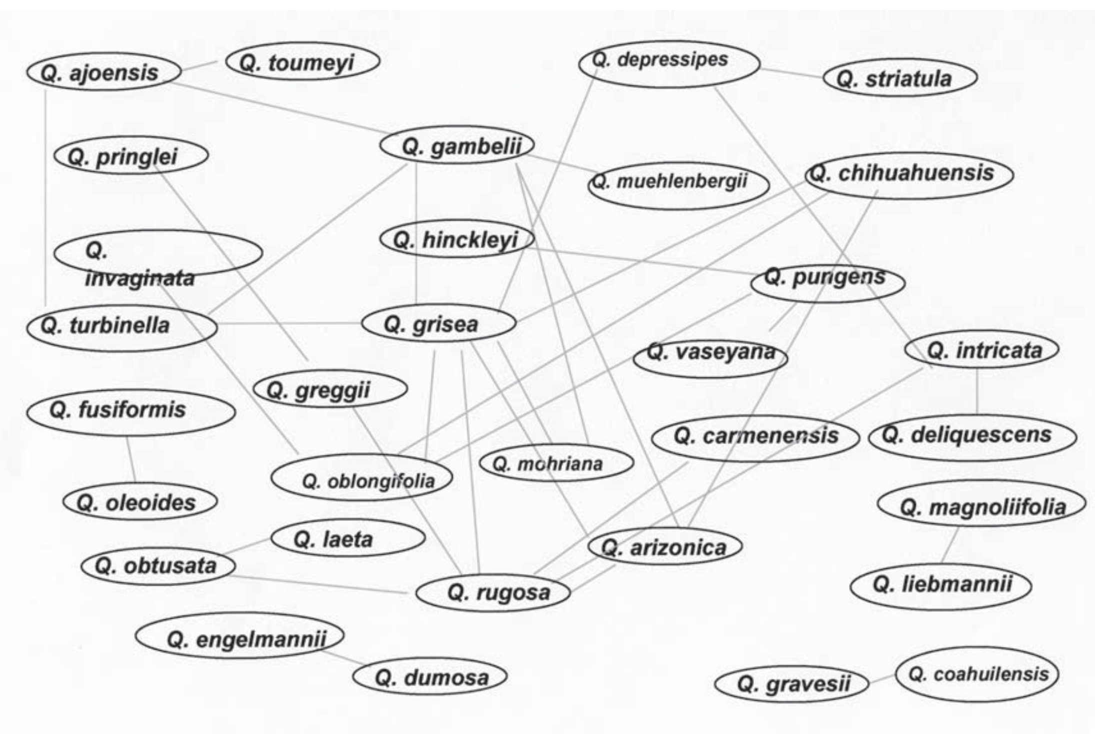

Figure 3. Hybridization documented or observed between some white oak species in Mexico.

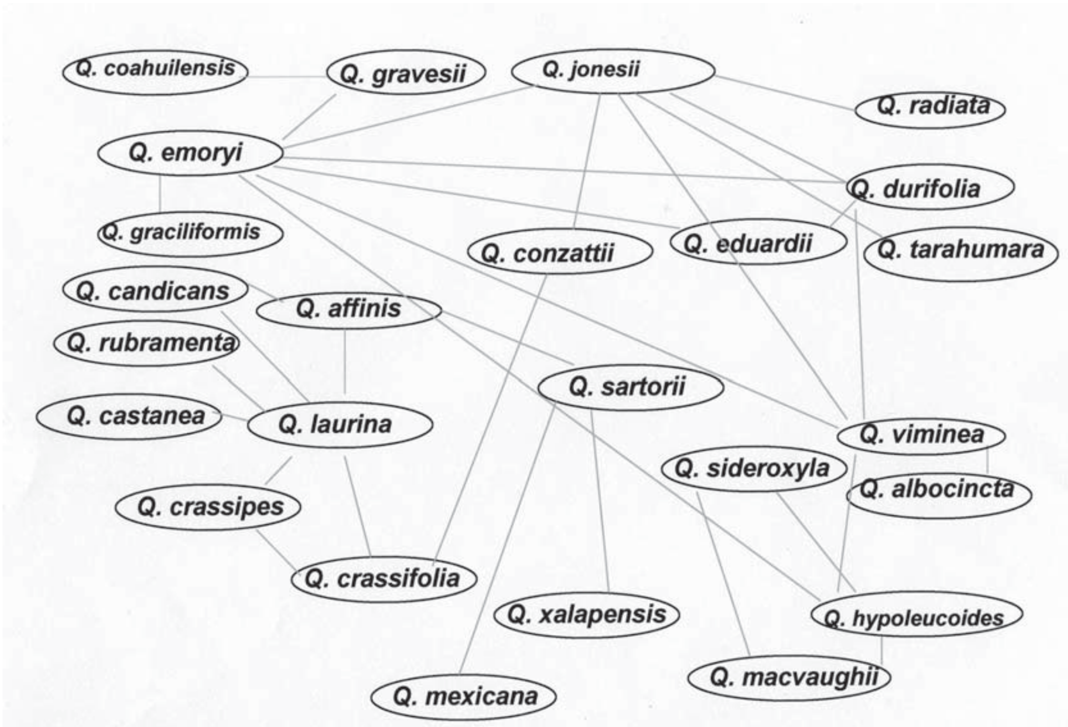

Figure 4. Hybridization documented or observed between some red oak species in Mexico.

nomenclature requires revision of the types and of the associated original descriptions. Unfortunately, much of the literature and the majority of the oak type specimens are outside the country. Only about 6.8% of the type specimens of the genus *Quercus* are in Mexican herbaria. Modern communications permit more easy access to this information, but there are still problems such as that of observing the details of the trichomes, which are often indispensible for identifying oaks at the species level and which cannot be seen in photographs of herbarium specimens; they can only be observed directly on the material, access to which can be expensive and often unaffordable.

Field Work. Most solutions to specific taxonomic problems require field work, because it is in so doing that the taxonomic variation of the species can be recognized. When collecting it is necessary to exercise caution to not label samples coming from different individuals with a single collection number, since it is only with accurate records that the recognition of intraspecific variation is possible. The information obtained by field work is invaluable, for which reason it is necessary to take maximum advantage of it, even though it is expensive and often highly dangerous in some regions of the country.

Characters of taxonomic value in the identification of species

In the genus *Quercus*, the mature leaves provide the most useful information for identification. The size, general form of the blade, of the apex, of the base, the number of veins, the type of margin, the consistency, and the color are very important; but by these alone it is possible to misidentify the material, for which reason it is necessary to consider everything all together and to include also the characters of the twigs, buds, stipules and fruit, which together permit a better identification of the species.

Despite the great value of the characters offered by the leaves for species recognition, it is necessary to take into account characters which converge because of the habitat type, such as is the case with consistency. For example, sclerophyllous leaves predominate in the species from high tablelands (the Central Altiplano in Mexico) and areas of semidesert, while in more humid and temperate zones, leaves tend to be more delicate.

Of all leaf characters, trichomes are the most useful: their type, size, the number of radii and the extent of fusion analyzed with the aid of a microscope; they provide, in most cases, the most constant characters which permit species identification in the most precise manner. This character has been explored in detail, resulting in important contributions, beginning with the pioneer work of Hardin (1979), the ample and detailed work of Jones (1986), up to the most recent and specific contributions of Manos (1993), Valencia and Delgado (2003) and Vázquez (2006). All of these trichomes analyzed by scanning electron microscope have furnished very valuable data for recognizing species.

In some taxonomic treatments (e.g. McVaugh 1974 and González Villarreal 1986) juvenile leaves have been described as elements characteristic of the species. But these do not provide stable characters because the size, consistency and certain types of trichomes are modified during their development. For this reason they are not useful for the recognition of species.

The male and female flowers of oaks have traditionally been considered as having little or no taxonomic value. Although there may be some differences in type of pubescence, in the length of pedicels and in the size and form of the tepals of the male flowers, all of these vary within species and converge between species. The scant specialization of the flowers, due possibly to wind pollination, may be the cause of this slight variation. Additional research on the characters of the flowers may yield information for characterizing some groups of species. For this are required more collections of flowers which are not well represented in herbaria.

The Diversity of Oaks in Mexico

Due to the great wealth of species, the oaks of Mexico have been the subject of almost constant taxonomic study, which begins with the description of 16 new species published by the Spaniard Luis Née (1801). Shortly afterwards Humboldt and Bonpland (1809) described another 20 species of Mexican oaks. Prominent subsequently are the descriptions of Liebmann (1854), the monographic work of Trelease on American oaks (1924), and the extensive study by Maximino Martínez of the oaks of Mexico (1953). Also important in this context are the contributions of Muller (1936, 1942a, 1942b), Nixon and Muller (1992, 1993) and Spellenberg (1992, 2001) on different regions in the north of our country, for which they describe various new species.

Later begin the formal taxonomic treatments of various regions of Mexico: Nueva Galicia (McVaugh 1974), Jalisco (González-Villarreal 1986), Michoacán (Bello & Labat, 1987), the Valley of Mexico (Espinosa-G 2002), Guerrero

(Valencia 1995 and Valencia *et al*. 2002), Puebla (Vázquez 1992), Mexico (Romero *et al*., 2002), and Aguascalientes (De la Cerda 1989).

These studies are not finished and at the present time the elaboration of taxonomic studies of the oaks of the Bajío (Central Plateau), Oaxaca, Hidalgo, San Luis Potosí, Veracruz, Coahuila and Tlaxcala is underway. Important also are works which furnish tools for the recognition of Mexican oak species such as the compilation of keys by Zavala-Chávez (2003) and the work of Soto-Arellano (2007), which offers a universal key (polykey) for Mexican oaks.

The number of species for the genus *Quercus* is as yet imprecise. The most recent data estimate that there exists in Mexico some 160 species, of which 109 are endemic (Valencia 2004), which means that Mexico possesses 32.2-40.2 % of the world total and approximately 75% of American species. Of the world total, estimated at between 400 and 500 species, a quarter is endemic in our national territory.

The numerous studies of different oak characters, of their distribution, of hybridization, of the progress in regional taxonomic treatments and the analyses of some complexes of Mexican species have permitted better recognition and understanding of the species. This has resulted in modification of the specific diversity of the genus in some regions and for Mexico in general, due not to the description of new species (during the last five years there have been none) or to modification of the total number of species (which basically remains the same), but to the reconsideration of the status of some of them or to the reconsideration of herbarium material, as can be seen in the following examples.

For *Q. pinnativenulosa* C.H. Mull. only the type specimen from Nuevo León was known, but recently it has been collected in Hidalgo, Querétaro, Tamaulipas, Veracruz and San Luis Potosí. In a similar position is *Q. furfuracea* Liebm., which was also known only from the type specimen, but which has now been collected in the states of Hidalgo, San Luis Potosí, and Puebla. *Q. ariifolia* Trel. has also been reconsidered as a species distinct from *Q. rugosa* Née (Valencia in prep.), and *Q. trinitatis* Trel. as different from *Q. laurina* Bonpl.

A different case is that of *Q. salicifolia* Née, previously treated as a species of broad distribution from Jalisco to Central America; but a review of herbarium material, including the type specimen, and field work, demonstrated that it has a very restricted distribution, only on the Pacific slope of the Sierra Madre del Sur and apparently only in Guerrrero. The treatment of *Q. salicifolia* as a species of broad distribution was due to the scant knowledge of this species and to the fact that all specimens which have narrow, lanceolate, glabrous leaves were erroneously identified as *Q. salicifolia*: *Q. eugeniifolia* Liebm. (from Central America); *Q. nixoniana* S. Valencia & Lozada-Pérez and *Q. laurina* Bonpl. from Oaxaca and Guerrero, *Q. benthamii* A. DC. from Chiapas, *Q. pinnativenulosa* C.H. Mull. and *Q. sapotifolia* Liebm. from the Gulf slope.

When speaking of the richness and diversity of species in Mexico it is necessary to refer to this by regions and by states. From the physiographic point of view, Mexican oak species are concentrated in the Sierra Madre Occidental, Sierra Madre Oriental, and Sierra Madre del Sur, but there are also important elements in the isolated mountains of Baja California, in the mountains of Chihuahua and Sonora, in the desert portion of the Central Altiplano, and in the

	SMOr	SOax	SMOcc	SMS	FVT	AC	BC	SChis
Totals	55	23	44	31	31	46	15	24
Lobatae	33	11	24	20	17	13	3	13
Lobatae endemic	14	0	8	8	2	2	2	1
Quercus	23	12	20	11	14	32	9	11
Quercus endemic	5	1	5	1	2	10	1	0
Protobalanus	0	0	0	0	0	1	4	0
Protobalanus endem	0	0	0	0	0	0	1	0

Table 1. Estimated wealth of species for the principal physiographic regions of Mexico.

SMOr = Sierra Madre Oriental
SOax = Sierra Norte de Oaxaca
SMOcc = Sierra Madre Occidental
SMS = Sierra Madre del Sur
FVT = Transmexican Volanic Belt
AC = Central Plateau (Altiplano)
BC = Baja California
SChis = Sierra de Chiapas

mountainous regions of Chiapas. Based on preliminary data we present next the estimated wealth of species for the principal physiographic regions of Mexico; these data are summarized in **Table 1**.

The Sierra Madre Oriental remains the most diverse region in Mexico; it contains around 55 species. 33 % belong to Section *Lobatae*, of which 14 are endemic, and 23 in Section *Quercus*, of which 5 are endemic. Prominent in this region is the highest number of endemics among red oaks stands, although this fact needs to be taken with caution, since some of these are known only from the type specimen.

Endemic species for this zone are the following: *Quercus cortesii* Liebm., *Q. cupreata* Trel., *Q. flocculenta* C.H. Mull., *Q. furfuracea* Liebm., *Q. galeanensis* C.H. Mull., *Q. graciliramis* C.H. Mull., *Q. hirtifolia* M.L. Vazquez et al., *Q. hypoxantha* Trel., *Q. miquihuanensis* Nixon & C.H. Mull., *Q. pinnativenulosa* C.H. Mull, *Q. rysophylla* Weath., *Q. tenuiloba* C.H. Mull., *Q. xalapensis* Bonpl., *Q. runcinatifolia* Trel., *Q. ariifolia* Trel., *Q. clivicola* Trel., *Q. edwardsiae* C.H. Mull., *Q. germana* Schltdl. & Cham., *Q. verde* C.H. Mull.

The Sierra Norte de Oaxaca. Some consider this a continuation of the Sierra Madre Oriental, but although it is evident that this region receives some influence from that mountain range, there is a certain physiographic discontinuity and for this reason it is treated here as a different region. In this zone there grow around 23 species, 11 are from Section *Lobatae* and 12 from Section *Quercus* with a single endemic species: *Q. macdougalli* Martínez.

The Sierra Madre Occidental. With an estimated 44 oak species, this physiographic region is in third place in oak diversity; 24 species are from Section *Lobatae*, of which 8 are endemic and 20 belong to Section *Quercus* with 5 endemic. The species endemic to this region are *Q. albocincta* Trel., *Q. aristata* Hook & Arn., *Q. durifolia* Seemen ex Loes., *Q. fulva* Liebm., *Q. macvaughii* Spellenb., *Q. coffeicolor* Trel., *Q. radiata* Trel., *Q. tarahumara* Spellenb., *Q. convallata* Trel., *Q. praeco* Trel., *Q. subspathulata* Trel., Q. ×*basaseachicensis* C.H. Mull. (*Q. depressipes* Trel. × *Q. rugosa* Née), and *Q. ignaciensis* C.H. Mull.

The Sierra Madre del Sur. The diversity of this range is relatively low; 31 species have been identified, 20 in Section *Lobatae,* 8 being endemic and 11 in Section *Quercus* with a single endemic species. The endemic species of this zone are *Q. cualensis* L.M. González, *Q. iltisii* L.M. González, *Q. mulleri* Martínez, *Q. nixoniana* S. Valencia & Lozada-Pérez, *Q. rubramenta* Trel., *Q. salicifolia* Née, *Q. tuitensis* L.M. González, *Q. uxoris* McVaugh and *Q. martinezii* C.H. Mull.

The Transmexican Volcanic Belt. Both the diversity and the endemism of this region are relatively low for the genus *Quercus*; revisions show that there are 31 species, of which 17 belong to Section *Lobatae* with two endemics and 14 are placed in Section *Quercus* with two endemics. The endemic species in this region are *Q.* ×*dysophylla* Benth. (*Q. crassipes* Bonpl. × *Q. crassifolia* Bonpl.), *Q. hintonii* E.F. Warb., *Q. frutex* Trel. and *Q. microphylla* Née.

The Central Plateau (Altiplano). This is the second most diverse region, it harbors around 46 species of oak, 13 belong to Section *Lobatae* with two endemics and 32 are from Section *Quercus* with ten endemics; *Q. chrysolepis* Liebm., which belongs to Section *Protobalanus*, also grows in this region. It is interesting to stress the high endemism of Section *Quercus* in the Altiplano. The endemic species are the following: *Q. gravesii* Sudw., *Q. tardifolia* C.H. Mull. (*Q. gravesii* × *Q. coahuilensis*), *Q. carmenensis* C.H. Mull., *Q. deliquescens* C.H. Mull., *Q. filiformis* C.H. Mull., *Q. hinckleyi* C.H. Mull., *Q. invaginata* Trel., *Q. potosina* Trel., *Q. pungens* Liebm., *Q. striatula* Trel., *Q. tinkhamii* C.H. Mull., and *Q. undata* Trel.

The Peninsula of Baja California. This is the least diverse of the regions analyzed. Found there are 16 species of oaks, with three from Section *Lobatae,* two endemic; nine belong to Section *Quercus* with one endemic, and four are in Section *Protobalanus* with one endemic. The endemic species in this region are *Q. devia* Goldman, *Q. peninsularis* Trel., *Q. brandegeei* Goldman, and *Q. cedrosensis* C.H. Mull. (the latter on Cedros Island).

Sierras de Chiapas. This region has continuity with the mountain ranges of Guatemala; it is thought to harbor 24 species with 13 in Section *Lobatae* and one endemic, while 11 are in Section *Quercus* without any endemics. The diversity of this zone could change with study, since it has received little attention and its relations with Central America are problematic. The only endemic species is *Q. duratifolia* C.H. Mull., which should also be reviewed.

Analysis of the Distribution of the Genus *Quercus* by Physiographic Region

The previously mentioned regions were analyzed in order to recognize the relationship which is evident among them, based on the distribution of oaks in

Mexico. The programs WinClada (Nixon 1999) and Nona (Goloboff 1977) for personal computers were utilized for this. A matrix was constructed with the eight physiographic regions indicated above with an additional hypothetical group which was considered a root (a total of 9 rows functioning as terminals) and 145 columns of the oak species (72 *Lobatae*, 69 *Quercus*, and four *Protobalanus*) which were considered as characters. Three kinds of analysis were done. The first used all included species; the second only those from Section *Lobatae* and the third, the white oaks. Data on *Protobalanus* were not utilized to do a separate analysis since there are only four species in this section.

Tree A in Figure 5 shows the results of the inclusion of the 145 species. In this one can appreciate the relationship which the Sierra Madre del Sur has with the Transmexican Volcanic Belt and the Peninsula of Baja California as a sister group of the clade which unites the Sierra Madre Occidental and the Central Altiplano. For their part, the Sierra Madre Oriental, the Sierra Norte of Oaxaca and the Ranges of Chiapas form a basal grade.

Tree B in Figure 5 shows the results when only red oaks are included. The same basal grade is found in this one. Subsequently The Central Plateau (Altiplano) and the Peninsula of Lower California form a clade which behaves as a sister group of the one formed by the Sierra Madre del Sur, the Sierra Madre Occidental and the Transmexican Volcanic Belt.

Tree C in Figure 5 was obtained by considering only the white oaks; in this one a grade is formed with the Central Altiplano in the base, followed by the Sierra Madre Occidental and this as a sister group of the clade formed by the Sierra Madre del Sur and the Transmexican Volcanic Belt on the one hand and

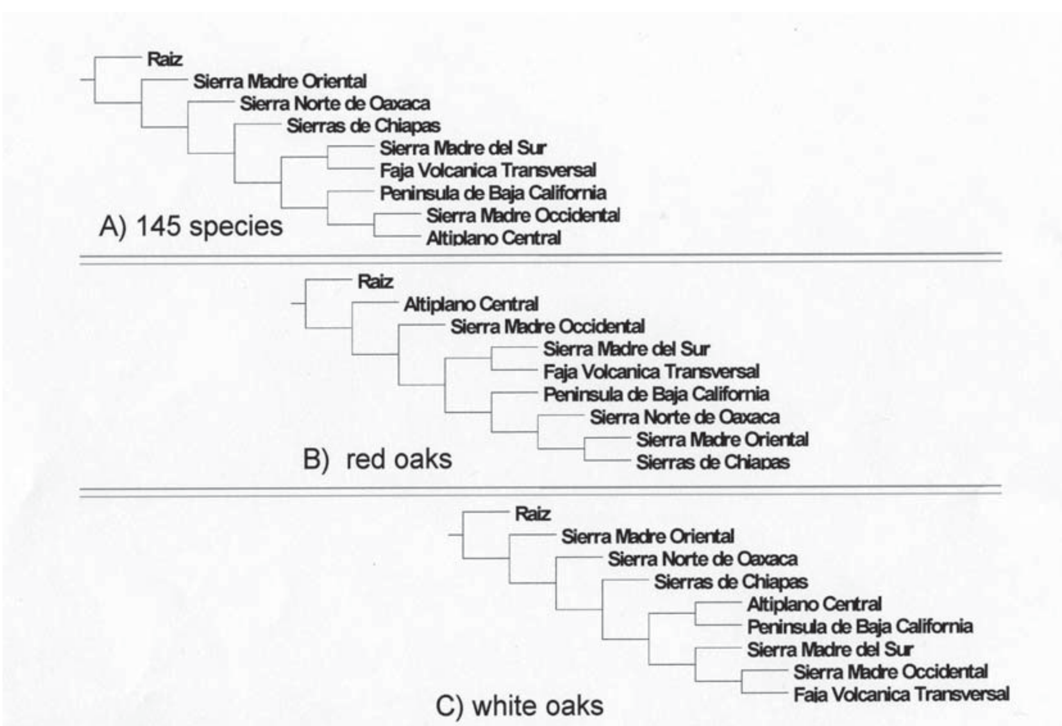

Figure 5. Analysis of the distribution of the genus *Quercus* by physiographic region. A) Tree with the inclusion of the 145 species. B) Tree with the inclusion of only red oaks. C) Tree with the inclusion of only white oaks.

on the other a grade with the Peninsula of Baja California and the Sierra Madre Oriental, while the Sierra Norte of Oaxaca and the Ranges of Chiapas form a more derived group.

The relationships shown in the cladograms indicate that the Sierra Madre Oriental, Sierra Madre Occidental and the ranges of the Central Altiplano have played an important role in the diversity and radiation of oaks, the first preferentially for the red oaks and the latter two for the white oaks.

On the other hand, in the context of the states, the numbers for specific diversity have been modified and in accordance with these, the state with the greatest richness of species is San Luis Potosí with 54, followed by Oaxaca with 50, following this is Nuevo León with 47, Jalisco with 45, Hidalgo with 42, Chihuahua with 40 and Veracruz with 39. The richness known for the rest of the states is equal or inferior to the last number.

The Sections of *Quercus* in Mexico. In Mexico there are three sections in the genus *Quercus: Protobalanus, Lobatae* and *Quercus*. Below is a brief summary of different important aspects of each of the sections of the subgenus *Quercus* in Mexico.

Golden cupped oaks (Section *Protobalanus*). Restricted to the American continent, this is the smallest section of the genus *Quercus*, with only five species. It is localized in the northwest of Mexico and the western-most states of the United States. In accordance with the phylogenetic analyses of Nixon (1993) and of Manos *et al*., (1999), this section is related to Section *Quercus* (or American white oaks) (Figure 2).

Of the five species recognized for Section *Protobalanus*, four, *Q*. *palmeri* Engelm., *Q*. *tomentella* Engelm., *Q*. *cedrosensis* C.H. Mull., and *Q*. *chrysolepis* Liebm. are present in Mexico, constituting 3% of Mexican oaks. The last is the species of greatest distribution and morphological variation of the four (Manos 1997).

All the oaks of this section are biennial fruiting, although due to their character of possessing perennial leaves, in which the leaves can last more than one year, they give a false appearance of being annual.

Red Oaks (Section *Lobatae*). This section is also endemic to the American continent; it has approximately 120 species distributed from North America to Colombia. In Mexico there are around 76, which constitute 48% of Mexican oaks (Valencia 2004).

In Mexico the red oaks dominate in regions of greater altitude and the more humid forests; they are less diverse in dry regions, although in some regions there may be exceptions in which some red oaks such as *Q*. *castanea* Née and *Q*. *urbanii* Trel. are more tolerant than the white oaks.

Section *Lobatae* is found towards the base of the phylogenetic tree of the sections of the Subgenus *Quercus*, implying that sections *Quercus* and *Protobalanus* are derived and are more closely related than they are to the red oaks (Nixon 1993, Manos *et al*., 1999) (Figure 2).

The maturation of the acorns of the red oaks may require two years in the species of greatest altitude and latitude, or one year in the more southern species or those growing in warmer and more humid zones, as for example *Q*. *salicifolia* Née, *Q*. *crispifolia* Trel. and *Q*. *nixoniana* S. Valencia & Lozada-Pérez.

There is a clear distinction among the sections of the genus *Quercus*. The red oaks display leaves with a margin that is either entire, lobed or dentate-aristate, the scales of the acorn cups are striped, the internal surface of the endocarp is tomentose, the abortive ovules are in apical position and the free perianth of the female flowers forms a rim. The anatomy and color of the wood also show differences and this latter gives a name to the two largest sections of oaks in America: *Lobatae* (red oaks) and *Quercus* (white oaks).

The majority of red oaks have wood with a light red tint and with vascular elements having a greater diameter, a round form, and thicker walls in comparison with those of the white oaks. In the same way, they have fewer tyloses in the vascular elements and therefore the wood is more porous than that of the white oaks, and it has little resistance to damage by fungus or insects. Several studies have been done on the anatomy of the wood of Mexican oaks. Among these, those of De la Paz (1976, 1982, 1985) and Valencia and Barajas-Morales (1995) stand out.

Mexican red oaks have received more attention than the white oaks. Various works have approached them in different ways, such as that headed by Dr. Ken Oyama in Morelia who, based on molecular data, carried out investigations on the phylogenetic relations of the red oaks, as well as diverse problems of hybridization.

Other teams, also experienced, are those of Dr. Antonio González Rodríguez, that of Dr. Efrain Tovar and of Dr Ana Mendoza, who study oak hybridization, while the first (González Rodríguez) treats, in addition, the relationship of the species and their morphology with the environmental conditions in which they grow. The section has also been approached in the biogeographical context by Torres (2009). Vázquez (2001), Valencia (2005), and Romero (2006), studied different complexes of red oaks from the taxonomic point of view, thus contributing to the taxonomic knowledge of this group.

The most problematic taxonomic groups in Section *Lobatae*. Described below are some groups of species which present frequent taxonomic problems or which are important because of their broad geographic spread. The groupings do not aim to include species which are related phylogenetically, since in the majority of cases there are no data for this, but they do seek to illustrate frequent taxonomic problems by including together the species which are confused with great frequency. It is sufficient to note that in the case of some species they could be counted in two or more groups.

The *Quercus laurina* group. This group is found in cold, humid zones in cloud forests, moist oak forests and forests of conifers and *Quercus*. Most of the species of this group have lanceolate leaves, with a pointed, bristled apex, dorsal and ventral surface glabrous or retaining only some clustered trichomes in the axils of the secondary veins. Included here are *Q. acherdophylla*, *Q. affinis*, *Q. laurina*, *Q. crassipes*, *Q. mexicana*, *Q. crispipilis*, *Q. depressa*, *Q. gentryi* C.H. Mull., *Q. benthamii*, *Q. rubramenta*, *Q. mulleri*, *Q. trinitatis*, *Q. pinnativenulosa*, *Q. viminea* Trel., *Q. emoryi* Torr., *Q. saltillensis* and *Q. salicifolia*. These species could in turn be segregated into subgroups which present particular problems, for example, *Q. crassipes*, *Q. mexicana*, and *Q. crispipilis*. This group is treated as based on the species of greatest distribution and apparently greatest promiscuity, *Q. laurina*, since the latter has been observed as hybridizing with *Q. affinis*, *Q. crassipes*, *Q. mexicana*, and *Q. rubramenta* of this group, as well as with *Q. crassifolia* and occasionally with *Q. candicans*.

The specimens of these species in herbaria are frequently confused, especially if they lack acorns, since the maturation time of one or two years permits differentiation of some of them, e.g. *Q. acherdophylla* is of annual maturation while *Q. laurina* is biennial. Requiring mention here is *Q. depressa* which, in contrast to the other species, is a shrub oak impossible to confuse in the field, but whose herbarium specimens show great similarity to *Q. affinis* and *Q. laurina*.

This group has been treated by Valencia (1994, 2005) through an analysis of different morphological characters and with phylogenetic analysis by González et al. (2004) using molecular data.

The *Quercus acutifolia* group. *Quercus acutifolia* Née is the best known species of this group and in fact many species included here have been erroneously identified as this. Its distribution is restricted to the Sierra Madre del Sur, the Transmexican Volcanic Belt and Sierra Madre Oriental. This group of species is characterized by lanceolate to elliptical leaves, glabrous on both surfaces, with some clustered trichomes in the axils of the veins and with a dentate-aristate margin. Apparently there is less hybridization among the species of this group than in the previous one and the majority of the species have a more restricted distribution. Included here are the species *Q. acutifolia*, *Q. albocincta*, *Q. canbyi* Trel., *Q. conspersa*, *Q. cortesii*, *Q. brenesii* Trel., *Q. furfuracea*, *Q. skinneri* Benth., *Q. paxtalensis* C.H. Mull., *Q. sartorii*, *Q. xalapensis*, and *Q. uxoris*.

The *Quercus castanea* group. This group is so named because *Q. castanea* is the species of broadest distribution and most abundant in herbarium collections. The species included are *Q. eduardii* Trel., *Q. castanea*, *Q. sideroxyla* Bonpl., *Q. scytophylla* Liebm. and *Q. hypoleucoides* A. Camus. The lower surface of leaves of *Q. castanea* can be completely covered by trichomes and then it gets confused with *Q. sideroxyla*, while more glabrous specimens can be confused with *Q. eduardii*. This group is being studied by the team of Dr. Ken Oyama in order to learn the relationships and possible degrees of hybridization among them using molecular data.

The *Quercus crassifolia* group. In this group are included *Q. fulva, Q. crassifolia, Q. conzattii* Trel., *Q. macvaughii, Q. tarahumara, Q. urbanii, Q. hypoleucoides*, *Q. hintonii*, and *Q. dysophylla*. Characterized by very leathery leaves completely tomentose on the lower surface; the upper surface has sunken veins giving it a rugose appearance. Some of the species of this group were treated by Vázquez in his doctoral dissertation (2001).

The case of *Q. dysophylla* must be emphasized; it was described as a new species by Bentham in 1840, but a hybrid nature was suspected due to the fact that only rare isolated individuals were observed in the field, and when only *Q. crassifolia* and *Q. crassipes* were present in sympatry. Tovar and Oyama (2004) studied this taxon both morphologically and from the molecular point of view, confirming that it is a hybrid formed by the crossing of these two species in sympatric surroundings. Unfortunately there are other problems, since hybridization between *Q. mexicana* and *Q. crassifolia* can produce morphology similar to that of *Q. dysophylla*, for which reason it is necessary to be careful when collecting.

White Oaks (Section *Quercus* sensu stricto). Section *Quercus* has a broad distribution in the Northern Hemisphere. In Mexico there are around 80 species which is equivalent to 49% of the total for the country.

White oaks are more tolerant of conditions of moisture stress, and for this reason they have a wider range of habitats than the red oaks; they can therefore be more common in dry regions than in moist surroundings, as indicated by their greater diversity and endemism in the region of the Central Plateau (Altiplano). Some exceptions may exist such as *Q. germana*, *Q. martinezii*, and *Q. macdougalli,* which are dominant and characteristic of humid oak populations and of cloud forests.

Section *Quercus* is a sister group to Section *Protobalanus*, both derived with respect to the *Lobatae* (Nixon 1993; Manos *et al.*, 1999) (Figure 2). Maturity of the acorns of white oaks is always annual and this is considered to be a derived characteristic in the maturation of the fruit of oaks.

White oaks have leaves with a lobed, toothed, or entire margin, but without bristles, present is only a mucron which can be sharp and give the false impression of a bristle; the scales of the cups of the acorns are frequently keeled, the internal surface of the endocarp is smooth and the abortive ovules are in a basal position. The vascular elements in the wood are smaller, having a somewhat angular form in a transverse cut and their walls are more delicate than those of the red oaks. They have tyloses which block the vascular elements in the heartwood and for this reason they are less liable to attack by fungus and insects; this property has been an advantage in the manufacture of barrels for aging alcoholic beverages.

In this section are placed the subsections Virentes and Glaucoideae, studied by Nixon (1984), who contributed important data on their taxonomy and ecology. Nixon holds that these subsections are characterized by the presence of fused cotyledons and at the time of germination, the hypocotyl-epicotylic axis is placed more deeply into the soil, giving protection to the young seedling. Nixon (2002) postulates that these are characteristics adaptive for desiccation and fire, since the species which constitute these groups are broadly tolerant of conditions of dryness.

The white oak group presents greater taxonomic difficulty and has received less attention. Only some species such as *Q. magnoliifolia* and *Q. resinosa* are undergoing study in order to understand their variation and hybridization. *Q. rugosa* has also received a great deal of attention because of its broad geographic and ecological distribution.

The most problematic taxonomic groups of Section *Quercus.* Below are described some groups of species which present frequent taxonomic problems or are important because of their broad geographic distribution. As mentioned earlier, the groups do not aim to include phylogenetically related species, but rather to demonstrate taxonomic problems.

The *Quercus rugosa* group. This may be one of the largest complexes because of the wide distribution of *Q. rugosa*. In this group are included, in addition to *Q. rugosa*, *Q. greggii*, *Q. ariifolia*, *Q. obtusata* Bonpl., *Q. laeta*, *Q. potosina*, and *Q. peduncularis* Née, characterized by obovate, occasionally broadly obovate or oblanceolate leaves, with the upper surface strongly rugose and the lower with clustered trichomes.

In this same group the problem is exacerbated between *Q. laeta* and *Q. obtusata*, including their consideration as a single species. *Q. laeta* is a problem because of the wide morphological variation that it shows, making its delimitation and identity more difficult.

The *Quercus magnoliifolia* group. This group is characterized by species with large obovate glabrous or tomentose leaves, with parallel secondary veins and dentate margins. Included here are *Q. magnoliifolia* Née, *Q. resinosa* Liebm., *Q. liebmannii* Oerst., *Q. muehlenbergii* Engelm., *Q. obtusata*. All of these can be easily confused if one is not careful to use a microscope to observe in detail the type of trichomes present. Hybridization among them is likely in areas of sympatry, which accentuates the problem. This complex is under investigation in the laboratory of Dr. Ken Oyama.

The complex of *Q. insignis* and *Q. oocarpa*. These two species of oaks from beautiful Mexican cloud forests are characterized by oblanceolate to obovate leaves with a dentate margin and parallel veins, the shoots and the lower surface of leaves with fasciculate trichomes having erect, golden radii and acorns the largest among American oaks, reaching 9 cm in diameter when fresh in *Q. insignis*. Unfortunately the differences between these two species are not very clear, as is their distribution. Small populations have been found in Veracruz, Oaxaca, and Chiapas which undoubtedly belong to *Q. insignis*; but rarer specimens, with smaller fruits and leaves, coming from Jalisco, Nayarit, and Guerrero raise doubts about the identity of these two species. These species are under study by the working group of Dr. Antonio González.

The group of shrub White Oaks. Included in this group are *Q. frutex* Trel., *Q. repanda*, *Q. intricata* Trel., *Q. microphylla*, *Q. grisea* Liebm., *Q. sebifera*, *Q. tinkhamii*, *Q. striatula*, *Q. pringlei*, *Q. depressipes*. All are shrubby, either growing very close to the ground or reaching a height of around a meter, sometimes, as *Q. grisea*, a small tree. Most of these species are poorly known and seldom collected with acorns. With the exception of *Q. sebifera*, *Q. pringlei*, and *Q. depressipes*, they have trichomes which cover the lower surface of the leaf. Herbarium specimens of these species possess similarities which cause many problems for their identification.

Conclusion. Mexico possesses the greatest wealth of species of the genus *Quercus*, brought about by diverse factors among which the physical geography of the country is prominent. Some of its mountains, strategically situated or isolated, have functioned as islands which allowed speciation and great endemism in Mexico. The continuity of the great mountain chains have functioned as corridors permitting the wide distribution of many other species such as *Q. laurina*, *Q. candicans*, *Q. crassifolia*, *Q. rugosa*, and *Q. polymorpha* Schltdl. & Cham.

The extraordinary diversity of the genus as well as its ecological and economic potential, give high priority to an increase in studies to learn more about this important genus. Although knowledge of oaks has increased considerably in recent years, there are still serious problems to resolve. Individually these problems are not exclusive to the oaks, but together, they make the taxonomic study of the genus difficult.

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Diversity of the Gall Oak (*Quercus faginea* Lam.) in the Iberian Peninsula

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Summary

Morphological study of the Gall Oak (*Quercus faginea* Lam.) complex from the Iberian Peninsula has demonstrated the presence of four different taxa: *Quercus faginea* subsp. *faginea* var. *faginea* Lam., *Quercus faginea* subsp. *faginea* var. *alpestris* (Boiss.) F.M.Vázquez, M.Gutiérrez & S.Ramos comb. nov. *Quercus faginea* subsp. *broteroi* var. *broteroi* (Coutinho) A.Camus, and *Quercus faginea* subsp. *broteroi* var. *tlemcenensis* (A.DC.) Trabut & Batt. The difference between these is most evident in the leaf morphology. A historical review of descriptions of the group shows a diversity of names based on variations associated with geographical distribution and morphological characteristics of the leaves. But it is noteworthy that many names are synonymous or refer to hybrids within the group. Parallel study of the morphological and geographical distribution of the taxa has revealed little correspondence between ecological and geographical factors and morphological characteristics. The final results show high diversity in the southern Iberian Peninsula for the Gall Oak complex, with less diversity in northern areas of the Peninsula.

Key Words: Taxonomy, Distribution, Morphology, Southern Iberian Peninsula, Chorology.

Introduction.

The *Q. faginea* groups have two distinctive species in the Mediterranean Basin: *Q. faginea* Lam., and *Q. infectoria* Oliv. We can recognize the two species by morphological characteristics of the leaves and peduncles: *Q, faginea* Lam. has leaves up to 12 cm long, with peduncles up to 5.5 cm long, whereas *Q. infectoria* Oliv. has leaves which average up to 8 cm in length, with average peduncles up to 2 cm in length. Marginal pubescence of the leaves and flower morphology are very close in the two.

The *Q. faginea* complex found in the western part of the Mediterranean area is one of the most diverse of all oak species and in which the parental type is more frequently expressed among hybrids found in the zone (Huguet del Villar, 1938; Huguet del Villar, 1949; Saenz de Rivas & Rivas Martínez, 1968; Vázquez, 1995). The Gall Oak complex is defined by a combination of factors such as the morphological diversity of the proposed taxa (Vicioso, 1950; Saenz de Rivas, 1967; El Abidine & Fennane, 1995), hybridization processes, and insufficient knowledge of the morphological range of the proposed taxa.

The objective of this work is two-fold: to study the morphological and geographical diversity and distribution of the Gall Oak complex in the Iberian Peninsula, and to review the historical treatment of the main taxa of the group.

Materials and methods

The study is based on a review of the historical names and a complementary morphological and geographical study of the materials from the Iberian Peninsula conserved in the herbarium of the Centro de Investigación-La Orden-Valdesequera (HSS).

The review of the historical names associated with the *Q. faginea* complex in the Iberian Peninsula (and adjacent territories such as North Africa) is based on study of type specimens and on original descriptions with their names of the Gall Oak from the western part of the Mediterranean Basin. All relevant proposed taxa were reviewed and assessed, although the synonyms and invalidly published names were not (Appendix 1).

Morphological study was accomplished through review of leaf characters: dimensions, margin morphology, abaxial surface pubescence and number of ribs.

The analysis and morphological characterizations were correlated with geographical study, because it is necessary to recognize possible influences from the environment on morphological traits. It was also necessary to ascertain whether the geographical distribution of the supposed taxa had any influence on the noted characters. Sixty morphological characters were studied, and the best and clearest representatives of the differences among the proposed taxa (rib numbers, length, width, surface area, and pubescence of the blade) were selected (Appendix 2, 3).

All the results will be shown together with the characters noted in the herbarium materials studied from the Jussieu family herbarium in Paris, (P-JU). These consisted of 150 consecutive vouchers of the Gall Oak complex from the Iberian Peninsula. (Appendix 1).

Results

Results will be shown in two sub-sections: 1) review of historical treatments, and 2) morphological and geographical analysis.

Review of historical treatments

Q. faginea Lam. Lamarck published three different species of Gall Oak from Portugal: *Q. humilis*, *Q. lusitanica* (with two varieties) and one rare species which he named *Q. faginea* (1785). The first and second species have similar descriptions; the second variety of the second species and the first species are actually the same taxon. Moreover, the materials/types conserved in P-JU are very variable, and very frequently correspond to the same taxon. Note that Miller had previously published a *Q. humilis* from England, possibly based on *Q. robur* materials (1768). This fact invalidates both of the names *Q. humilis* Lam. and *Q. humilis* Mill. and partially also *Q. lusitanica* Lam. A *nominum conservatum* proposal for *Q. lusitanica* Lam. is probably advisable, as has been mentioned by Schwarz (1964). In addition, the *Q. lusitanica* concept is broad and overlaps with the concept of *Q. faginea* Lam. This was the main obstacle to the correct identification of *Q. faginea* during the first years of the twentieth century, and many researchers regard as *Q. lusitanica* the material associated with *Q. faginea*.

The type specimen of *Q. faginea* Lam., conserved in P-JU, shares features with three other proposed taxa: *Q. valentina* Cav., part of *Q. alpestris* Boiss., and part of *Q. australis* Link. Camus`s proposal (1936-39) to change the name *Q. lusitanica* Lam to *Q. faginea* is probably the best solution for the correct understanding of the Gall Oaks' diversity in the *Q. faginea* complex (See Lamina 1).

Q. valentina Cav. Cavanilles (1793) included a new name for the Gall Oak, which had been described previously by Lamarck (1785) as *Q. lusitanica* Lam. The opinion of Cavanilles (1793) was that the concept of *Q. lusitanica* Lam. was too broad and that the proposed new species, *Q. valentina* Cav., was justified because it showed differences in the length and the morphology of the leaves. He finally relegated *Q. lusitanica* Lam. (the prior and valid name) to the list of synonyms of *Q. valentina* Cav. By the rules of the International Code of Botanical Nomenclature, however, this name is invalid because it subordinates a validly published prior name.

Cavanilles (1793) also does not comment on the other taxa which had been established by Lamarck in 1785, although he asserts that *Q. valentina* Cav. is very close in the morphology of its leaves to *Q. lusitanica* Lam In fact, Cavanilles (1793) was describing the same taxon which had been previously described by Lamarck (1785) as *Q. faginea* Lam.

Finally, the morphotype described by Lamarck (1785) and the one indicated by Cavanilles (1793) were very close, because the leaves on both were serrate, with spines, ovate-lanceolate, sub-pubescent below, and from medium to short in length. Two descriptions were supplied for the morphology of the leaves.

Q. australis Link. Researchers such as Saenz de Rivas point out (1967) that *Q. australis* Link is close to *Q. faginea* s.s., but the original description by Link (1831) states "..*fol. ovalibus basi cordata mucronato-dentatis subtus tenui pubescentibus*." In fact, the leaves of *Q. faginea* Lam. are not cordate and are normally attenuate.

The notion of leaf pubescence is similar to that in *Q. faginea* Lam., which has short hairs on the underside of the leaf. These are characters typical of the lectotype of *Q. faginea* Lam. (P-JU)**.**

The mixture of characters, e.g. cordate leaves with medium pubescence, suggests a hybrid, e.g. *Q. faginea* subsp. *broteroi* × *Q. faginea* subsp. *faginea*. *Q. australis* Link is probably a hybrid between the two taxa just cited and is typical for Southern Portugal.

The latter proposal is supported by Saenz de Rivas (1967), where he indicates that the distribution of hair types in *Q. australis* Link *sensu* Vicioso and Saenz de Rivas has hair length between *Q. faginea* subsp. *broteroi* and *Q. faginea* subsp. *faginea*.

Q. alpestris Boiss. Boissier (1838) recognized a new oak from Málaga which was clearly different from *Q. faginea* Lam., *Q. valentine* Cav., and *Q. pseudosuber* Desf. because of the nature of the margin and surface of the leaves.

He also indicated that the new taxon had oblong-lanceolate leaves and short deciduous pubescence ("*minusve tomentosis deciduis*") on the underside of the leaf. The new species grows at altitudes higher than 1,000 m mixed with *Abies pinsapo* Boiss., in areas with high humidity and with snow cover for part of the year.

The morphology of the leaf is close to *Q. faginea* Lam. (Schwarz, 1936); Saenz de Rivas (1967) confirms the proximity/distance between the leaves of *Q. faginea* when these are compared with those of *Q. alpestris* Boiss. Later on, Blanca & al. (1999) show the different morphology of the leaf shape and the margin. Amaral (1990) and Govaerts & Frodin (1998) think that they are the same taxon. The list of opinions and authors could beextended, but exemplars of putative *Q. alpestris* Boiss. have leaves with crenate and mucronate margins, while those of *Q. faginea* Lam. have leaves with serrate margins. The pubescence in the two cases is similar. Finally the leaves of putative *Q. alpestris* have greater length than width, whereas the leaves of *Q. faginea* are equal in size or a little longer than they are wide. In our opinion *Q. alpestris* is close to *Q. faginea*, and it may possibly be a simple variation associated with a particular habitat (see Lamina 2).

Q. pseudosuber* var. *tlemc[s]enensis A.DC. The main characteristic indicated by Alphonse De Candolle (1864) for separating the new taxon was glabrous anthers. But variations associated with pubescence of the anthers are numerous. We can find in a single population of *Q. faginea* Lam. independent exemplars with high and medium pubescence and pilose to smooth anthers.

Deep/shallow dentate margins on the leaf is the second character indicated by De Candolle. As seen before, we can state that the enormous variations associated with characteristics of the margin and the size of the blade are not characters useful for discrimination of taxa in the *Q. faginea* complex.

Moreover, the pubescence associated with the abaxial surface of the leaf is both a new character and one which is irrelevant for the possible segregation of the taxon, because long hairs and high pubescence on the underside of the leaf are typical of other taxa in the group, e.g. *Q. faginea* subsp. *broteroi* (Coutinho) A.Camus.

We consider finally the "tlemcenensis" concept in the *Q. faginea* group. As a taxon alongside *Q. faginea* subsp. *broteroi* (Coutinho) A.Camus, with an oblong blade (longer than wide and a little serrate or dentate), this should probably be regarded as a simple variation, with the taxonomic level of *forma* (see Lamina 3).

***Q. lusitanica* var. *broteroi*[i]** Coutinho. The south-western Iberian Peninsula is characterized by the presence of evergreen oaks such as *Q. rotundifolia* Lam., *Q. suber* L. and *Q. coccifera* L., together with one deciduous oak: *Q. faginea* subsp. *broteroi* (=*Q. lusitanica* var. *broteroi* Coutinho). This oak occurs in mountains with *Q. faginea* subsp. *faginea* and *Q. pyrenaica* Willd.

Arid growing conditions, strong light, high temperatures, and poor soils explain some of the features of the Lusitanian Gall Oak: medium to large leaves, mucronate to crenate margins, tomentose underside with long and diverse hairs, pilose anthers, pubescent, long, sub-deciduous leaves. In this it is similar to new taxa such as *Q. lusitanica* subsp. *navarrana* O.Schwarz, proposed by Schwarz (1936-37) for the northwestern part of the Iberian Peninsula. Schwarz associates these traits with arid growing conditions, not to possible hybridization between *Q.*

robur × *Q. faginea* (under *Q. lusitanica*).

All authors nowadays recognize this as an accepted taxon, but some such as Rivas Martínez & Saenz de Rivas (1991) accord it *species* rank. Others (Carvalhos& Amaral, 1954; Amaral, 1990; Govaerts & Frodin, 1998) - the great majority - consider the taxon to be a *subspecies*. Studies investigating the proximity of *Q. faginea* subsp *faginea* and *Q. faginea* subsp. *broteroi* are abundant and always conclude that there is indeed a high similarity in type of habitat, in leaf and flower morphology, and in part, in flowering period. There also possibly exist fertile hybrids between the two taxa, which make the segregation of the two subspecies difficult (see Lamina 4).

Quercus lusitanica* var. *maroccana Braun-Blanq. & Maire. This is an oak "species" found in northwest Africa among populations of Evergreen Oak (*Q. rotundifolia* Lam.) and in cedar forests (*Cedrus atlantica* (Endl.) Carrière) there. The main characteristics of this taxon are traits associated with the leaves: large, with a crenate to dentate margin and a slight pubescence on the bottom surface. The leaves remind us of *Q. lusitanica* var. *mirbeckii*, sensu Braun-Blanque & Maire (1924), but they are more coriaceous

Study of the type specimen shows a Gall Oak similar to *Q. lusitanica* var. *broteroi* (Coutinho 1888) with large leaves and short pubescence. The petiole, size of the leaves, and general morphology are reminiscent of the leaves of *Q. canariensis* Willd. In fact, the materials associated with the type specimen display a combination of characteristics between *Q. lusitanica* var. *broteroi* and *Q. canariensis*. It is thus possible that *Q. lusitanica* var. *maroccana* is an African hybrid between *Q. canariensis* and *Q. faginea* (*Q. lusitanica* var. *broteroi*), as was suggested by Camus (1936-39).

Morphological and geographical analysis

Morphological analysis reveals the presence of numerous overlapping characters. The discrimination of taxa in the Gall Oak complex in the Iberian Peninsula is based on combinations of foliar characters. Figure 1 shows the distribution of the results for the surface of the leaf in the four putative taxa. "Faginea" and "alpestris" show the smallest leaf surface, intermediate leaf surface is represented by "broteroi", and the greatest size of leaf surface is represented by examples of "tlemcenensis".

The relation '2 × number of secondary ribs + 2 × pubescence density' is another character identifying the four groups in the Gall Oak complex. The "broteroi" and "tlemcenensis" groups show the maximum value for this parameter, while the lowest value is in the "alpestris" group; the "faginea" examples have intermediate value.

Other morphological characters were evaluated and contrasted. Valid results were obtained for density of pubescence on the bottom surface of the leaf. The rest of the characters analyzed did not yield valid criteria for the identification and segregation of the potential taxa. These include morphology of the leaf margin, petiole length, pubescence on the upper leaf surface, number of ribs, length and width of the blade, acorn size, morphology of the cupules, and the type of hairs on the leaves and the reproductive organs.

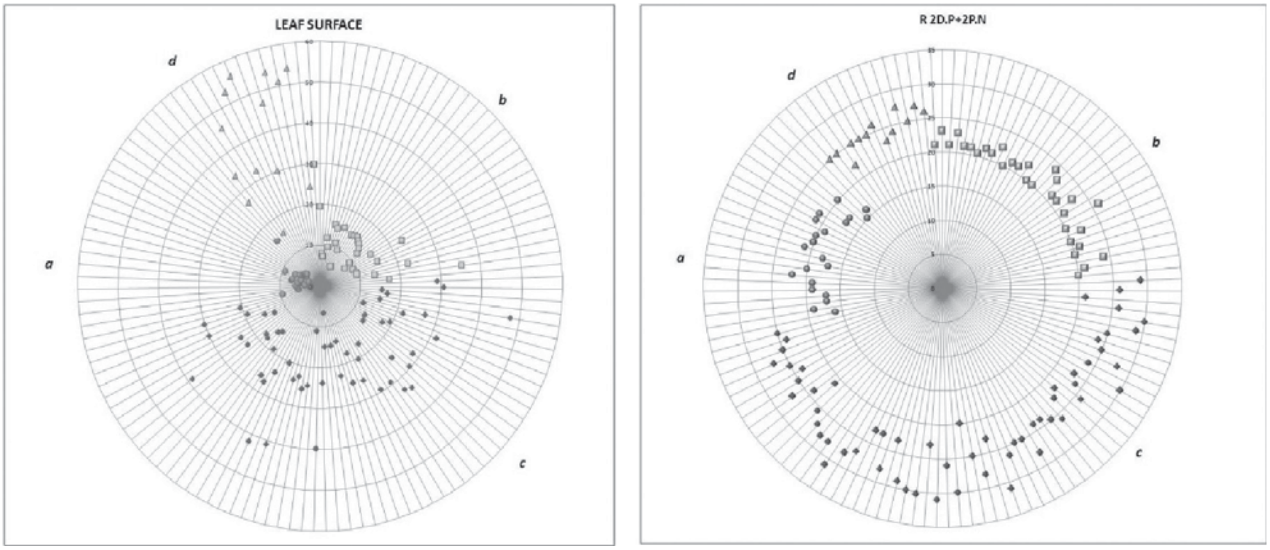


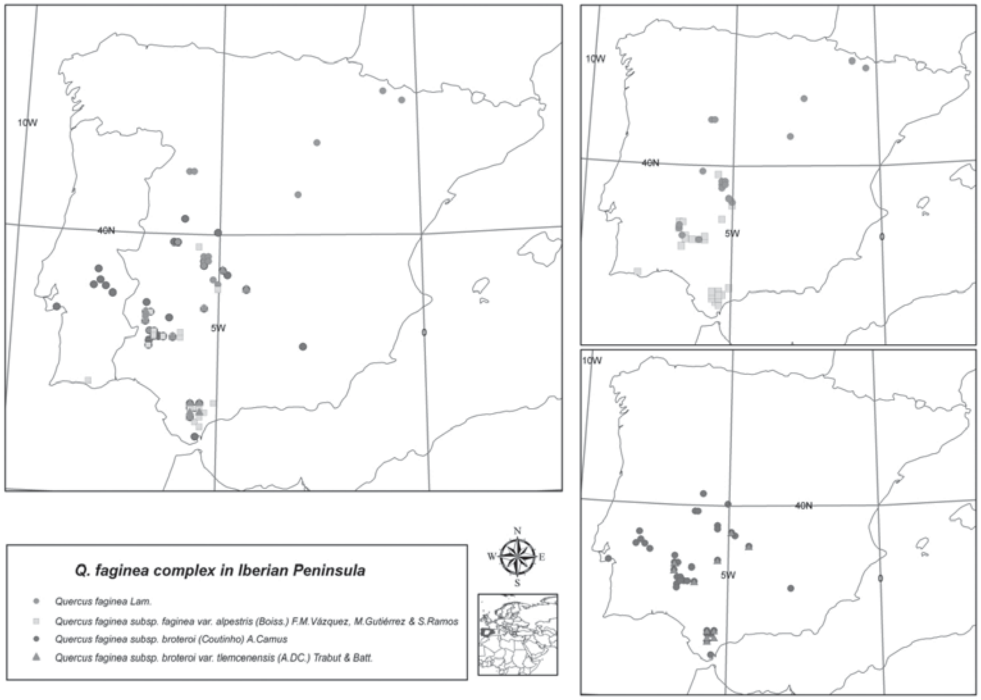
Figure 1. Distribution of results for the relation “2 × number of secondary ribs + 2 × pubescence density on the lower leaf surface” (**R 2D.P+2P.N**) and “Leaf surface value” (**LEAF SURFACE**), for the four groups of the Gall Oak studied from the Iberian Peninsula studied: **(b)** “alpestris”, **(c)** “broteroi”, **(a)** “faginea” and **(d)** “tlemecenensis”.

When analyzed according to geographical distribution, the potential groups did not reveal differences. The latitude, longitude, and altitude considered for the four groups show irregular distribution in all cases. But there are definitely patterns in the distribution of the “alpestris”, “broteroi” and “tlemecenensis” groups in the southern part of the Iberian Peninsula, while the “faginea” group appears throughout in the same geographical area (see Figure 2 and Map 1).

Discussion and conclusions

Consideration of historical treatments combined with new morphological study suggest several potential morphologically related taxa, although they would not necessarily be accepted, since morphological differences can result from different environmental conditions. Frequent hybridization in the group is another source of confusion and the basis for creation of new taxa. Finally, the geographic distribution of morphological characters, combined with hybridization, have caused different names and taxa to be proposed, which has increased confusion in the Gall Oak complex.

With revision of names, and the proposal of specific morphological groups, we can define four clear groups that can be differentiated by the following keys:



Map 1. Distribution of the Gall oak taxa from the Iberian Peninsula studied here: *Q. faginea* subsp. *faginea* var. *alpestris* (yellow), *Q. faginea* subsp. *broteroi* var. *broteroi* (red), *Q. faginea* subsp. *faginea* var. *faginea* (blue) and *Q. faginea* subsp. *broteroi* var. *tlemecenensis* (green).

Figure 2. Distribution of results for the geographical characters **Latitude** (º) and **Altitude** (m), for the four groups of the Gall Oak from the Iberian Peninsula studied here: ■ **(b)** "alpestris", ◆ **(c)** "broteroi", ● **(a)** "faginea" and ▲ **(d)** "tlemecenensis".

Keys for identification of the Gall Oak complex of the Iberian Peninsula

1.- Small to average leaf blade, up to 3.5 cm wide. Leaf underside glabrous to glabrescent ………………………………………………………………… **2.**

1.- Average to large leaf blade 2.5-6.5 cm wide. Leaf underside glabrescent to pubescent ……………………………………………………..…………… **3.**

2.- Leaf underside glabrous to sub-glabrous, up to 2.5 cm wide
Q. faginea **subsp.** ***faginea*** **var.** ***faginea***

2.- Leaf underside glabrescent, up to 3.5 cm wide
Q. faginea **subsp.** ***faginea*** **var.** ***alpestris***

3.- Leaf underside pubescent, 4-8(10) cm long
Q. faginea **subsp.** ***broteroi*** **var.** ***broteroi***

3.- Leaf underside glabrescent to pubescent, 7-13 cm long
Q. faginea **subsp.** ***broteroi*** **var.** ***tlemcenensis***

Based on review of the morphological characters, geographical distribution and historical treatment, we propose the following taxonomic scheme for the Gall Oak complex from the Iberian Peninsula:

Quercus faginea Lam., *Encycl. (Lamarck)* 1(2): 725. 1785 [1 Aug 1785]. (Lectotype: P-JU, nº 17093! Lower exemplar) (See Lamina 1)
<u>Synonymous</u>: *Quercus valentina* Cav., *Icon*. 2: 25, tab. 129 (1793) ex descr., nom illeg. = *Quercus faginea* Ten. *Syll. Pl. Fl. Neapol*.: 469 (1831), nom. illeg. = *Quercus lusitanica* subsp. *faginea* (Lam.) A.DC. in A.P.de Candolle, *Prodr.* 16(2): 17 (1864) ≡ *Quercus lusitanica* subsp. *faginea* (Lam) A.DC. in *A.P. de Candolle, Prodr.* 16(2): 17 (1864) ≡ *Quercus lusitanica* var. *valentina* (Cav.) A.DC. in A.P.de Candolle, *Prodr.* 16(2): 17 (1864). ≡ *Quercus lanuginosa* var. *faginea* Nyman, *Consp. Fl. Eur*.: 661 (1881) = *Quercus lusitanica* f. *microphylla* Coutinho, *Bol. Soc. Brot*. 6: 69 (1888) ≡ *Quercus lusitanica* f. *vulgaris* Coutinho, *Bol. Soc. Brot*. 6: 68 (1888), nom. inval. ≡ *Quercus faginea* subvar. *vulgaris* (Coutinho) A.Camus, *Chênes, Atlas* 2: 113 (1935), nom. inval. ≡ *Quercus lusitanica* subsp. *valentina* (Cav.) O.Schwarz, *Cavanillesia*: 8: 72 (1936) ≡ *Quercus faginea* subvar. *microphylla* (Coutinho) A.Camus, *Chênes, Texte* 2: 180 (1939) ≡ *Quercus faginea* subsp. *eufaginea* A.Camus, *Chênes, Texte* 2: 172 (1939), nom. inval. ≡ *Quercus lusitanica* var. *vulgaris* (Coutinho) C.Vicioso, *Rev. Gen. Quercus Esp*.: 107 (1950), nom. inval. ≡ *Quercus faginea* var. *oscensis* P.Monts., *Bull. Soc. Échange Pl. Vasc. Eur. Occid. Bassin Médit*. 22: 62 (1988).

Quercus faginea* subsp. *faginea* var. *alpestris (Boiss.) F.M.Vázquez, M.Gutiérrez & S.Ramos **comb. nov.** (See Lamina 2)
<u>Basionym</u>: *Quercus alpestris* Boiss., *Elech. Pl. Nov*.: 83 (1838) (Lectotype: G-BOIS!)
<u>Synonyms</u>: *Quercus lusitanica* subsp. *alpestris* (Boiss.) Nyman, *Consp. Fl. Eur*. 661 (1881) ≡ *Quercus lusitanica* f. *microcarpa* Coutinho, *Bol. Soc. Brot*. 6: 68 (1888) ≡ *Quercus lusitanica* var. *alpestris* (Boiss.) Coutinho, *Bol. Soc. Brot*. 6: 68 (1888) ≡ *Quercus alpestris* var. *vulgaris* (Coutinho) A.Camus, *Chênes, Texte* 2: 166 (1939), nom. inval. ≡ *Quercus alpestris* var. *microcarpa* (Coutinho) A.Camus, *Chênes, Texte* 2: 166 (1939) ≡ *Quercus faginea* subsp. *alpestris* (Boiss.) Maire, *Fl. Afrique Nord* 7: 100 (1961).

Quercus faginea* subsp**. ***broteroi (Coutinho) A.Camus, *Chênes, Texte* 2: 179 (1939) (See Lamina 3)
<u>Basionym</u>: *Quercus lusitanica* var. *broteroi* [i]Coutinho, *Bol. Soc. Brot*. 6: 68, Est. 1 figs. H-K (1888)
<u>Synonyms</u>: *Quercus hybrida* Brot., *Fl. Lusit*. 2: 31 (1805) = *Quercus lusitanica* var. *boissieri* (Reut.) A.DC. in A.P.de Candolle, *Prodr.* 16(2): 18 (1864) = *Quercus lusitanica* var. *hybrida* (Brot.) Nyman, *Consp. Fl. Eur*. 661 (1881) = *Quercus lusitanica* f. *macrophylla* Coutinho, *Bol. Soc. Brot*. 6: 69 (1888) = *Quercus lusitanica* f. *vulgaris* Coutinho, *Bol. Soc. Brot*. 6: 69 (1888), nom. inval. = *Quercus lusitanica* subsp. *broteroi* (Coutinho) Mouill., *Traité Arbr. Arbriss*.: 1162 (1892) =

Quercus faginea subvar. *macrophylla* (Coutinho) A.Camus, *Chênes, Atlas* 2: 113 (1935) ≡*Quercus lusitanica* subsp. *navarrana* O.Schwarz, *Repert. Spec. Nov. Reg. Veg.*, 38: (1936) ≡ *Quercus faginea* subsp. *broteroi* (Coutinho) A.Camus, *Chênes, Texte* 2: 179 (1939) ≡ *Quercus faginea* subvar. *bullata* (Coutinho) A.Camus, *Chênes, Texte* 2: 180 (1939) ≡ *Quercus faginea* var. *bullata* (Coutinho) A.Camus, *Chênes, Texte* 2: 178 (1939) ≡ *Quercus faginea* var. *eubroteroi* A.Camus, *Chênes, Texte* 2: 179 (1939), nom. inval. ≡ *Quercus broteroi* (Coutinho) Rivas Mart. & Sáenz de Rivas, *Rivasgodaya*, 6: 104 (1991).

Quercus faginea* subsp. *broteroi* var. *tlemcenensis (A.DC.) Trabut & Batt., *Fl. Alg.*: 21 (1888) (See Lamina 4)
Basionym: *Quercus pseudosuber* var. *tlemcenensis* A.DC, in A.P.de Candolle *Prodr.* 16(2): 44 (1864)
Synonyms: *Quercus lusitanica* subvar. *sublobata* Coutinho, *Bol. Soc. Brot.* 6: 69 (1888) ≡ *Quercus lusitanica* f. *submembranacea* Coutinho, *Bol. Soc. Brot.* 6: 67 (1888) ≡ *Quercus lusitanica* f. *salicifolia* Coutinho, *Bol. Soc. Brot.* 6: 68 (1888) ≡ *Quercus faginea* var. *tlemcenensis* (A.DC.) Jahand. & Maire, *Cat. Pl. Maroc* 2: 165 (1932) ≡ *Quercus tlemcenensis* Huguet del Villar, *Trab. Lab. Bot. Fac. Sc. Alger* 452 (1938) ≡ *Quercus faginea* subvar. *sublobata* (Coutinho) A.Camus, *Chênes, Texte* 2: 180 (1939) ≡ *Quercus faginea* var. *submembranacea* (Coutinho) A.Camus, *Chênes, Texte* 2: 177 (1939) ≡ *Quercus lusitanica* var. *salicifolia* (Coutinho) C.Vicioso, *Rev. Gen. Quercus Esp.* 108 (1950) ≡ *Quercus lusitanica* var. *submembranacea* (Coutinho) C.Vicioso, *Rev. Gen. Quercus Esp.* 112 (1950) ≡ *Quercus faginea* subsp. *tlemcenensis* (A.DC.) Maire & Weiller ex Greuter & Burdet, *Willdenowia* 12(1): 44. (1982).

The area with the greatest diversity in the Gall Oak complex is concentrated in the southern portion of the Iberian Peninsula, especially in areas of low altitude, with habitat shared by populations of Cork Oak (*Quercus suber* L.) and Algerian (Mirbeck's) Oak (*Quercus canariensis* Willd.).

Finally, hybridization is probably the source of two taxa associated with *Q. faginea* in historical treatments: *Q. australis* Link (= *Q. faginea* subsp. *faginea* × *Q. faginea* subsp. *broteroi*) and *Quercus lusitanica* var. *maroccana* Braun-Blanq. & Maire (=*Q. canariensis* × *Q. faginea* [*Q. lusitanica* var. *broteroi]*)

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Appendix 1

MATERIALS STUDIED

Quercus faginea* Lam. subsp. *faginea* var. *faginea

SPAIN: HS: BADAJOZ: Garbayuela HSS 7276; Hoya Santa María HSS 6154; Puerto Peña, HSS 5424; Cabeza de la Vaca, Tentudía, HSS 4814; Calera de León, Tentudía, HSS 4813; Valle de Matamoros, HSS 17766; Valle de Santa Ana, arroyo de los molinos, HSS 2458; Valle de Santa Ana, HSS 17648. CÁCERES: Guadalupe, El Humilladero, HSS 5207; Guadalupe, HSS 5206; La Calera, HSS 17882; Navalvillar Ibor, HSS 2507; Navatrasierra, HSS 11151. GUADALAJARA: Torija, márgenes de carretera, HSS 7532; Torija, HSS 7498. HUESCA: Sabiñaningo, HSS 2427; Valle Ansón, HSS 7565. SALAMANCA limite Zamora, HSS 3394; Valdelosa, HSS 16859. SORIA Calatañazor, HSS 10152; Calatañazor alrededores, HSS 10153.

***Quercus faginea* subsp. *faginea* var. *alpestris* (Boiss.) F.M.Vázquez, M.Gutiérrez & S.Ramos**

SPAIN: HS: BADAJOZ: El Pintado, HSS 4632; Fuente de León, HSS 3720; Hoya Santa María, próximo al pueblo, HSS 6128; Hoya Santa María, alcornocales, HSS 6121; Hoya Santa María, HSS 6132; Jerez Caballeros, HSS 1224; Salvaleón, localidad, HSS 6614; Salvaleón, hacia Salvatierra, HSS 17633; Salvaleón, HSS 6523; Siruela, HSS 11463; Valle de Matamoros, HSS 25907. CÁDIZ: Alcalá de los Gazules, HSS 10391; Algar, HSS 10520; Arcos de la Frontera, HSS 10381; Castellar de la Frontera, HSS 10349; El Bosque, HSS 10323; Puerto de Galis, HSS 10459; Puerto de Galis a Arcos de la Frontera, HSS 10458; Jimena de la Frontera, localidad, HSS 10342; Jimena de la Frontera, HSS 10344; Ubrique, HSS 10445. CIUDAD REAL: Puebla de Don Rodrigo, límite provincial con Badajoz, HSS 6404; Puebla de Don Rodrigo a límite con Badajoz, HSS 6403; Luciana, HSS 6391. MÁLAGA: Cortes de la Frontera, localidad, HSS 1079; Cortes de la Frontera, HSS 10372; Gaucin, localidad, HSS 10339; Gaucin, HSS 1033; Ronda, HSS 1220

PORTUGAL: LU: ALGARVE: Sierra Calderon, HSS 6466.

***Quercus faginea* subsp. *broteroi* var. *broteroi* (Coutinho) A.Camus**

SPAIN. HS: BADAJOZ: Cabeza la Vaca, HSS 1108; Cíjara, HSS 6572; Cíjara hacia Orellana, HSS 6585; Cíjara, hacia Herrera del Duque, HSS 6586; Fregenal, hacia Higuera la Real, HSS 3479; Fregenal, HSS 3732: Hoya Santa María, hacia Puebla del Maestre, HSS 5506; Hoya Santa María, HSS 6108; Jerez Caballeros, HSS 1227; Jerez Caballeros, localidad, HSS 2486; La Parra, HSS 5030; Monesterio, HSS 7235; Salvaleón, HSS 6527; Salvaleón, localidad, HSS 6538; Salvaleón, hacia Salvatierra, HSS 6619; Salvatierra Barros, HSS 4988; Salvatierra Barros, hacia Salvaleón, HSS 13054; Segura León, HSS 1098; Tentudía, HSS 4966; Valle de Santa Ana, HSS 1323; Valle de Santa Ana, arroyo de los molinos, HSS 3488; Zafra, HSS 16908. CÁDIZ: Algar, HSS 10518; El Bosque, HSS 10326; Puerto de Galis hacia Arcos, HSS 10450; Galis, HSS 10454;

Grazalema, HSS 4824; Ubrique, HSS 10441; Ubrique, localidad, HSS 10446. CÁCERES: Piornal, HSS 5530; Serradilla, HSS 5562; Villareal hacia Torrejón el Rubio, HSS 5806; Villareal, HSS 5807. CIUDAD REAL: Puebla de Don Rodrigo, límite provincial con Badajoz, HSS 6399; cerca Luciana, HSS 6375; Luciana, localidad, HSS 6423; Luciana, HSS 6444. GUADALAJARA: Torija, HSS 7535. HUELVA: Galaroza, HSS 8523; Santa Ana, alrededores, HSS 5220; Santa Ana, HSS 5221. JAÉN: Cazorla, HSS s/n. MÁLAGA: Gaucin, localidad, HSS 10329; Gaucin, HSS 10334. TOLEDO: Navalcán, HSS 16729.

PORTUGAL. LU: ALENTEJO: Avis a Cano, HSS 6837; Avis, HSS 6839; Cabeçao, alcornocal, HSS 6806; Cabeçao, localidad, HSS 6926; Cabeçao, HSS 6941; Cano, HSS 5344; Estremoz, hacia Portalegre, HSS 6770; Estremoz, HSS 6771; Ponte do Sor, HSS 5296. ALGARVE: Sierra Calderon, HSS 6464; Sierra Calderon, HSS 6465. ESTREMADURA: Arrabida, HSS 7493; Setubal, HSS 7454

***Quercus faginea* subsp. *broteroi* var. *tlemcenensis* (A.DC.) Trabut & Batt.**

SPAIN. HS: BADAJOZ: Cíjara, HSS 6571; Hoya Santa María, HSS 5499; Salvaleón, hacia Salvatierra, HSS 6611; Salvaleón, HSS 6563; Salvatierra Barros, HSS 1114; Valle de Matamoros, HSS 25908; Valle de Santa Ana, HSS 3466. CÁDIZ: Arcos de la Frontera, HSS 10384; Puerto de Galis, HSS 10463; Grazalema, HSS 4826; Ubrique, HSS 10379. CÁCERES: Navatrasierra, HSS 11155. CIUDAD REAL. Puebla de Don Rodrigo, proximidades al límite con Badajoz, HSS 6436; Luciana, HSS 6383.

Appendix 2

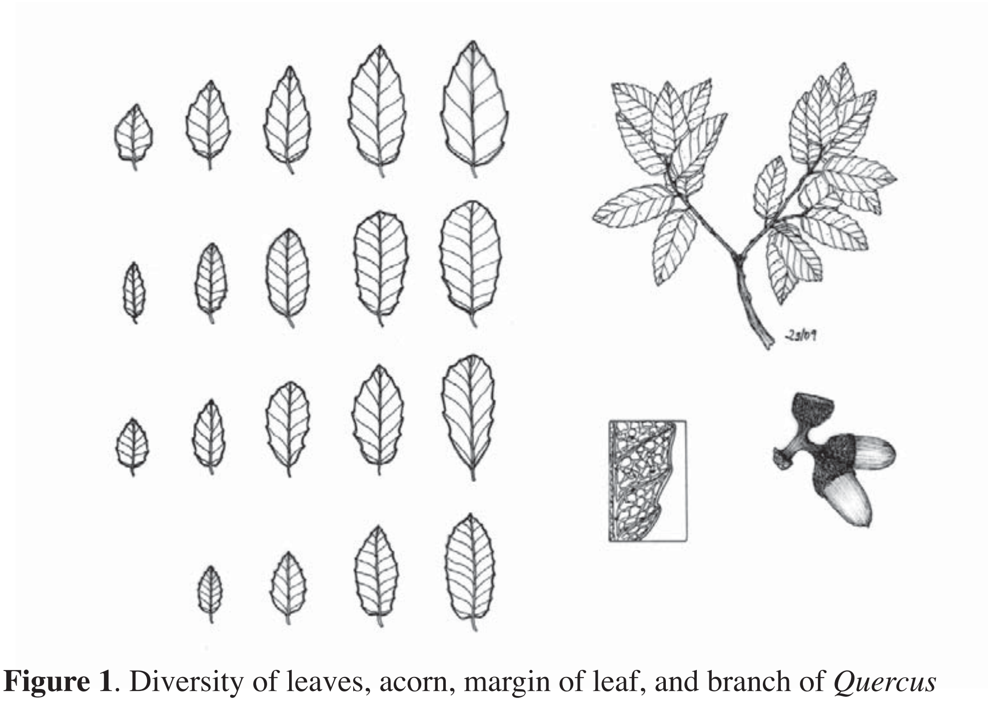

Figure 1. Diversity of leaves, acorn, margin of leaf, and branch of *Quercus* subsp. *faginea* var. *faginea* Lam.

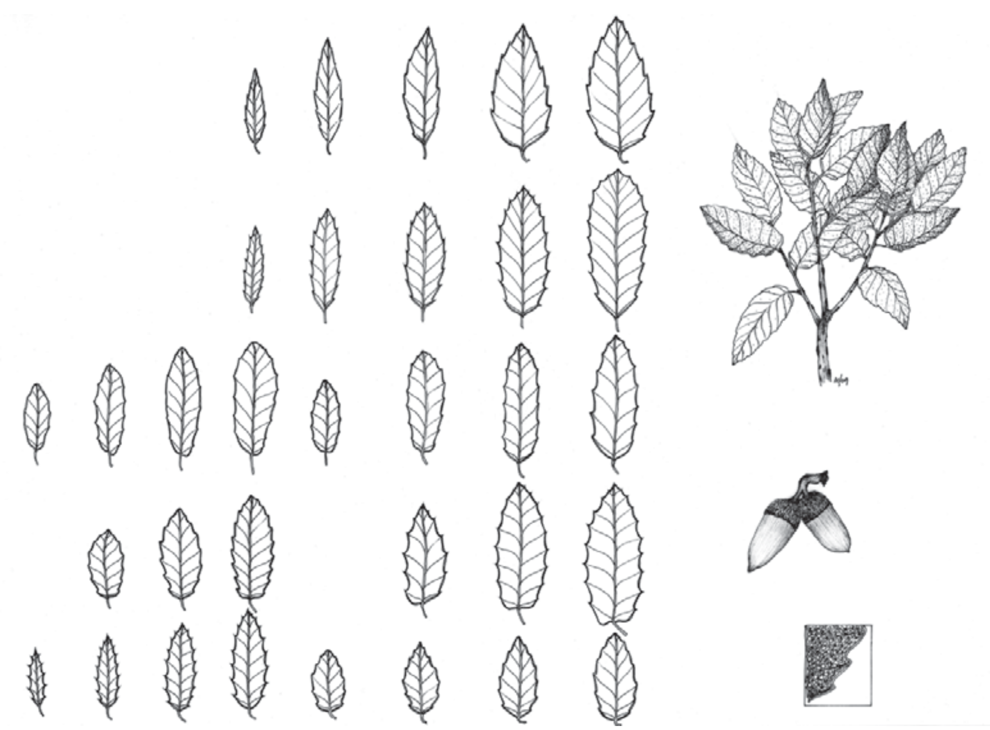

Figure 2. Diversity of leaves, acorn, margin of leaf, and branch of *Quercus faginea* subsp. *faginea* var. *alpestris* (Boiss.) F.M.Vázquez, M.Gutiérrez & S.Ramos.

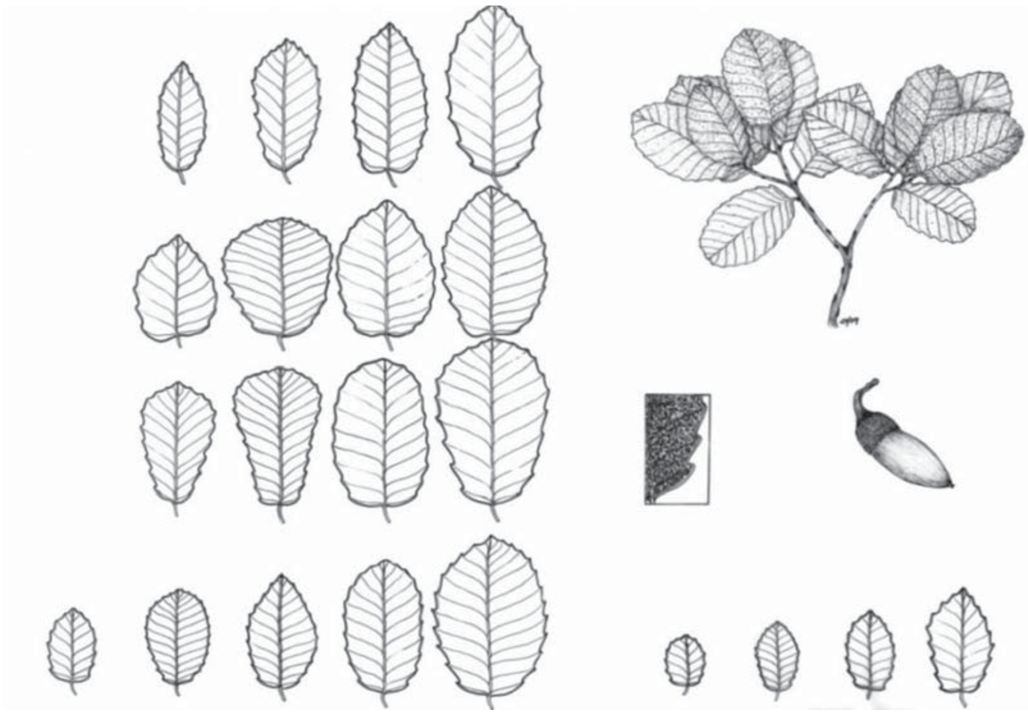

Figure 3.

Diversity of leaves, acorn, margin of leaf, and branch of *Quercus faginea* subsp. *broteroi* (Coutinho) A.Camus.

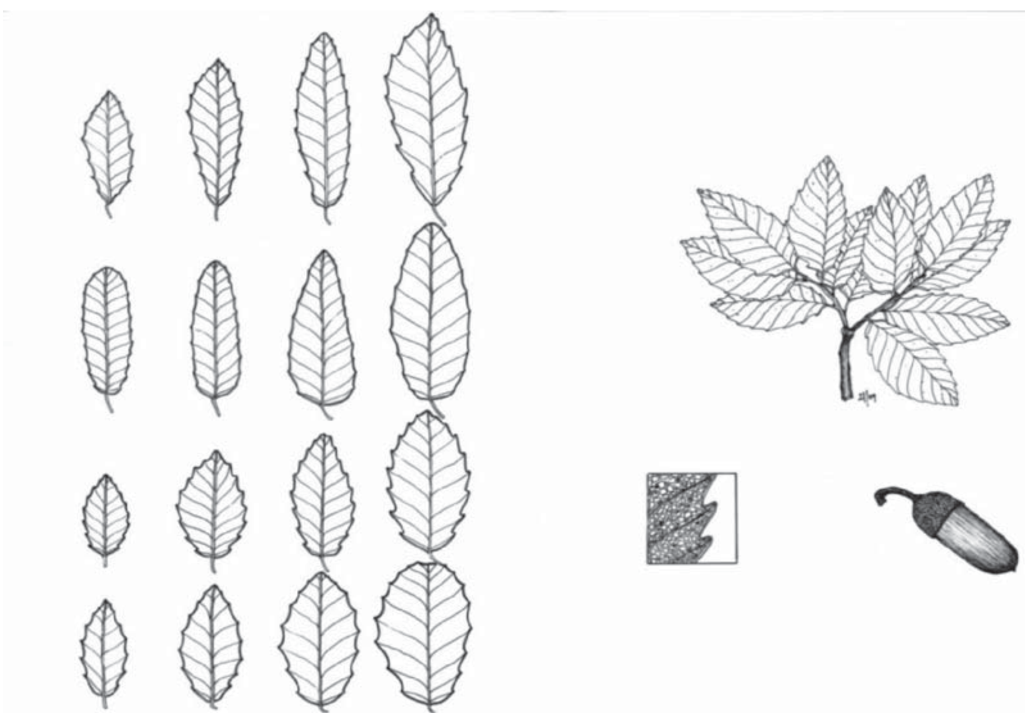

Figure 4.

Diversity of leaves, acorn, margin of leaf, and branch of *Quercus faginea* subsp. *broteroi* var. *tlemcenensis* (A.DC.) Trabut & Batt.

Appendix 3 Morphological Characters Studied

LEAF
1. Length of the blade (cm)
2. Width of the limb (cm)
3. Petiole length (mm)
4. Petiole section
5. Margin type
6. Margin pubescence
7. Adaxial pubescence
8. Abaxial pubescence
9. Surface of the blade
10. Number of ribs
11. Rib types
12. Enervation types
13. Adaxial hair types
14. Abaxial hair types

MALE FLOWERS
15. Catkin length (mm)
16. Number of flowers per catkin
17. Catkin pedicel length (mm)
18. Catkin pubescence
19. Petal length (mm)
20. Petal width (mm)
21. Petal margin
22. Petal pubescence
23. Anther length (mm)
24. Anther pubescence
25. Anther color
26. Filament length (mm)
27. Filament pubescence
28. Filament section

FEMALE FLOWERS
29. Inflorescence present
30. Number of flowers per inflorescence
31. Number of flowers per branch
32. Flower length (mm)
33. Flower width (mm)
34. Flower pubescence
35. Cupule length (mm)
36. Cupule width (mm)
37. Cupule pubescence
38. Cupule bract morphology
39. Cupule bract imbrications
40. Peduncle length (mm)
41. Peduncle pubescence
42. Insertion peduncle-cupule type

FRUIT
43. Length (mm)
44. Width (mm)
45. Weight (gr)
46. Surface color
47. Surface pubescence
48. Surface type
49. Cupule morphology
50. Cupule length (mm)
51. Cupule width (mm)
52. Cupule pubescence
53. Cupule bract morphology
54. Cupule bract imbrications

BUD MORPHOLOGY
55. Length (mm)
56. Width (mm)
57. Bract secondary morphology
58. Bract primary morphology
59. Bract margin
60. Bract pubescence

Abstracts and Posters

Quercus repanda

Quercus ×dysophylla

Quercus trinitatis

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Quercus castanea photo©Guy Sternberg

Quercus laeta photo©Guy Sternberg

Allometric Relationships of Two Oak Species Under Management for Traditional Charcoal Making

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One of the main economic activities of rural communities in the Cutizeo basin in Central Mexico is charcoal making using traditional techniques. Among the most frequently used species are *Quercus castanea* Née and *Q. laeta* Liebm., which are the most representative (along with *Q. deserticola*) in terms of distribution, abundance and basal area.

Forests and rangelands managed for charcoal making in the study area show the typical morphology of sprouting oaks. No allometric equations have been reported so far for oak sprouts, although it would be expected that DBH *vs* biomass relationships vary with respect to unharvested oaks.

A regression equation was calculated for each species being wood-suitable for charcoal, making (log(Y)) a function of sprouts' DBH (Log(X)). A third equation was developed for both species. Data was collected taking advantage of business-as-usual harvesting of oaks during charcoal making. Equations resulted as follows: *Q. castanea* (logY=9.52+2.63logX, R^2= 0.97, n=115); logY = 9.52564 + 2.63loyX *Q. laeta* (logY=9.39+2.69logX, R^2=0.98, n=17); and mixed equation (logY=9.41+2.59logX, R^2=0.96, n=132).

Currently, we are completing the study with data from *Q. deserticola* (n=40). Results from the present analysis will be used to estimate the sprouting productivity within experimental plots with varying startup regrowth dates (harvest events occurring since 1975 to present). The final objective of the project is to help design sound management strategies for oak rangelands in the study area.

Gene flow through pollen in a fragmented Mexican landscape

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INTRODUCTION

Gene flow within and among populations is a critical parameter of evolutionary processes, such as population differentiation. Pollen flow has been considered the most important component of gene flow in plants that are wind pollinated and produce large and immobile seeds.

Currently, human land use for agriculture and development has transformed large natural ecosystems into fragmented landscapes, significantly modifying gene flow patterns and genetic diversity.

OBJECTIVES

To estimate nuclear genetic diversity in *Quercus castanea* populations in fragmented landscape.

To evaluate gene flow levels from the heterogeneity of pollen pools accepted by individual seed parents.

METHODS

This study was performed in the catchment basin of Cuitzeo lake, Mexico (~4000 km^2)

Currently, this region is characterized by a high degree of forest fragmentation occurring within the last years. The basin has more than 1200 oak forest fragments.

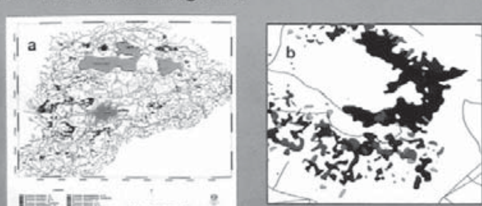

Fig 1. a) Map of Cuitzeo basin showing oak forest fragments, and b) enlargement of a small region of the basin.

We collected foliar tissue from
4 populations in different fragments
16 isolated trees throughout he basin
And acorns from each tree

Genetic parameters were evaluated using seven nuclear microsatellites (Aldrich *et al.*, 2002).

RESULTS

Great genetic diversity in all populations in both cohorts.

Gene flow diminish in progenies, principally in isolated progenies, which are strongly structured.

Heterogeneity of pollen pool was lower in isolated trees.

Table 1. *Genetic diversity in adults and progenies of Quercus castanea* populations and isolated trees

	Adults							Progenies						
Pob	n	N_a	N_e	A_p	H_e	H_o	F	n	N_a	N_e	A_p	H_e	H_o	F
JMB	16	9.429 (0.99)	5.558 (0.89)	0.714 (0.28)	0.777 (0.06)	0.769 (0.06)	-0.022 (0.05)	156	12.86 (1.37)	6.398 (1.04)	0.286 (0.28)	0.737 (0.07)	0.792 (0.06)	0.075 (0.05)
JMP	16	9.857 (1.28)	6.168 (0.68)	1.429 (0.36)	0.813 (0.04)	0.822 (0.02)	0.001 (0.07)	156	14 (1.57)	7.025 (0.94)	1.429 (0.36)	0.734 (0.04)	0.839 (0.02)	0.125 (0.04)
Corr	16	8.429 (0.84)	5.694 (0.63)	0.429 (0.20)	0.741 (0.07)	0.812 (0.02)	0.087 (0.09)	153	14.29 (1.56)	6.837 (0.94)	0.429 (0.20)	0.683 (0.05)	0.836 (0.02)	0.183 (0.06)
Ume	16	9.714 (1.32)	6.448 (1.04)	1.857 (0.59)	0.75 (0.08)	0.801 (0.04)	0.062 (0.09)	153	16.43 (1.91)	7.711 (1.33)	2.429 (0.42)	0.769 (0.06)	0.829 (0.04)	0.076 (0.04)
Average	16	9.357 (0.54)	5.967 (0.39)	1.107 (0.33)	0.77 (0.03)	0.801 (0.02)	0.032 (0.03)	154.5	14.29 (0.80)	6.993 (0.51)	1.143 (0.57)	0.731 (0.03)	0.824 (0.02)	0.115 (0.02)
Isolated trees														
Average	16	9.857 (0.73)	6.616 (0.98)	2.28 (0.18)	0.795 (0.04)	0.815 (0.04)	0.024 (0.03)	9.62	4.554 (0.15)	2.711 (0.09)	0.116 (0.03)	0.688 (0.02)	0.571 (0.01)	-0.221 (0.04)

n= mean sample size, N_a= mean number of allele, N_e= mean effective number of allele, A_p= mean number of private alleles, H_e= expected heterozygosity, H_o= observed heterozygosity, *F*= Fixation index.

Table 2. *F* statistics for *Quercus castanea* populations and isolated trees. * P< 0.05.

	F_{is}	F_{it}	F_{st}
Adults	0.110*	0.127*	0.018
Progenies	0.104*	0.138*	0.038*
Isolated adults	-0.019		
Isolated progenies	-0.120	0.157*	0.247*

Table 3. Gametic heterogeneity among the pollen pools

	Φ_{ft}	N_{ep}	δ	A_{ep}
JMB	0.233 *	2.142	6.67 m	0.03 ha
JMP	0.212 *	2.358	7.32 m	0.04 ha
Corr	0.215 *	2.326	10.78 m	0.09 ha
Umc	0.232 *	2.155	7.19 m	0.04 ha
Isolated trees	0.351*	1.424		

CONCLUSION

- Both sets of individuals (adults and progenies) posses high genetic diversity
- Progenies from isolated trees showed loss of alleles
- Inbreeding is acting on populations and isolated trees in different ways.
- Isolated adults are strongly structured.
- Isolated trees have less gametic heterogeneity of pollen pools

Gene Flow through Pollen in a Fragmented Mexican Landscape

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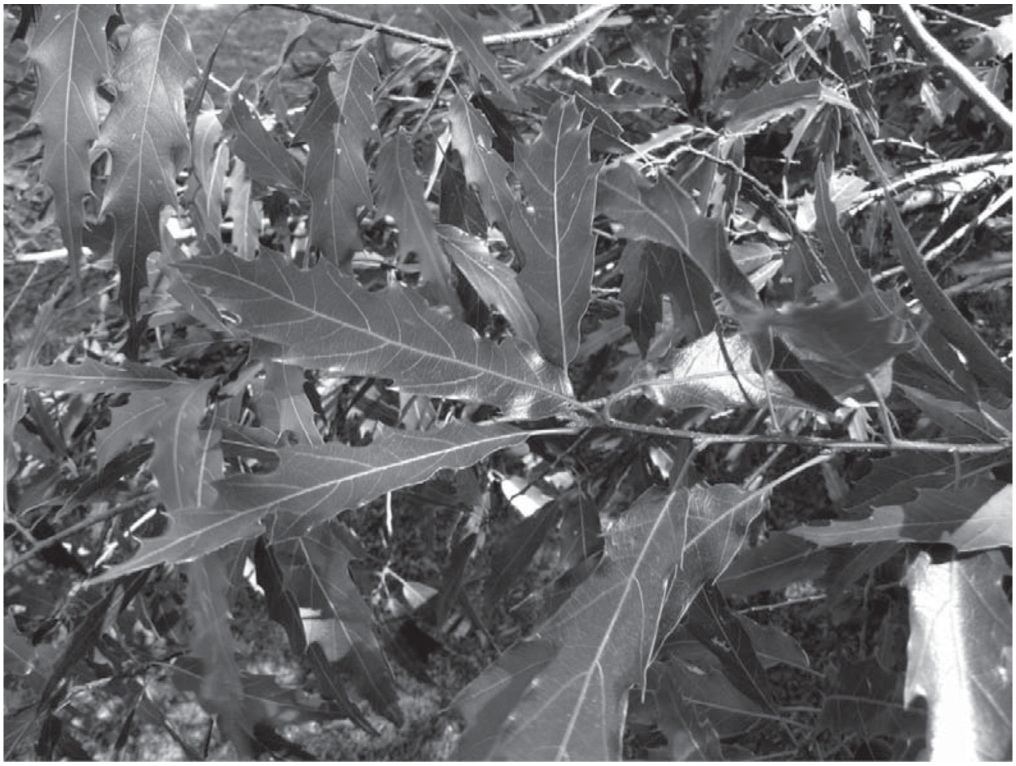
Gene flow is an important factor in the evolution of natural populations, and consequently is a critical parameter to shape genetic structure. Pollen flow has been considered as the major component of gene flow, especially in wind pollinated plants; therefore, it is a very important factor in maintaining genetic connectivity among populations. This pollen flow is not independent of environmental context and is very important to evaluate how processes like habitat fragmentation could affect these patterns.

Within the last four decades, *Quercus* forests of the Cuitzeo Basin in Mexico have been dramatically reduced to a large number of small patches of variable size. The goals of this research were to evaluate the genetic diversity and contemporary gene flow in a fragmented landscape. We sampled 16 maternal trees and collected seeds from every one, in four different isolated stands. We germinated the seeds and screened polymorphism at seven microsatellite loci. We found very high genetic diversity levels in adults Ho=0.77, He=0.8, and progenies Ho= 0.73, He=0.82, overall in different fragments. Only progenies populations were genetically structured. We found significant pollen structure across maternal trees with two-gene analysis. All populations were highly outcrossed, but biparental inbreeding is present.

We may conclude that the effect of forest fragmentation was moderated because both sets of individuals (maternal trees and progenies) maintain high genetic diversity levels. Nevertheless, genetic connectivity is lost in progeny populations.



Quercus acutifolia photo©Guy Sternberg

Quercus laeta photo©Guy Sternberg

Quercus mexicana photo©Guy Sternberg

Quercus polymorpha
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Reforesting or Restoring? The Case of the Oaks

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During recent years there has been a trend of "reforestation" in places close to urban areas, but it is known that many individuals that are planted will not survive the following year; the key to success in this is in using species native to the area. The "reforestation campaigns" were started 16 years ago in Africam Safari, and these campaigns have borne fruit beginning five years ago. The first planted trees were endemic species from Valsequillo Valley, which began to be disrupted some time ago.

There are three abundant species in this area, *Quercus mexicana*, *Quercus acutifolia* and *Quercus laeta*, which can survive in degraded soils due to their drought resistance. Experiments with oaks from other states have been carried out successfully due to the speed of germination, emergence of plumules and growth rate. The species that have most rapid growth are *Quercus polymorpha, Quercus germana,* and *Quercus eugeniifolia*. In addition, *Quercus greggii* and *Quercus microphylla* also have a rapid rate of maturation and resistance to water stress, and form large shrubs. Thus, the species of this genus are vital for reforestation, which provides medium- and long-term soil formation, water storage, and habitat for wildlife. We are therefore encouraging a "restoration" of our habitats, and not just reforestation.

The Utility of Arboreta and other Common Gardens of Oaks for Studying Ecology and Evolution

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Arboreta balance diverse uses - from picnickers to gardeners to scientists. Each use has its individual requirements for the management of an arboretum, but all share in their desire to explore the majesty and diversity of trees. While the needs of recreational arboretum-users are fairly straight-forward, ecologists or evolutionary biologists that visit arboreta look for fairly specific (and perhaps seemingly convoluted!) management practices that would maximize the utility of the arboretum as a resource for studying the ecology, physiology, and evolution of those trees. In this article, I would like to highlight some of the aspects of oak arboreta that make them most useful for scientists. At a time when there is particular interest in increasing oak collections at arboreta across North America through such concerted efforts as the North American Plant Collections Consortium (NAPCC) (Griswold 2009) and individuals with a particular interest in oaks, a list of arboretum attributes that make them ideal for researchers seems useful.

For the past three years, I have been exploring the evolutionary relationships between oaks and the ability of insects to colonize those diverse oak taxa. Much of my work has taken place in the UC Davis arboretum's Shields Oaks Grove, which was established by John Tucker (a renowned oak taxonomist), and represents one of the most useful scientific oak collections in the United States. As an evolutionary biologist and astute observer of oak natural history, Dr. Tucker had certainly taken many factors into account when planting the Oaks Grove that are now realized in making those trees especially useful for scientific studies. My intention with this article is to showcase some of these factors, not to suggest that arboreta that are differently organized are doing something wrong; arboreta have many uses, and some of those attributes that make them more useful for scientists may make them less desirable for other users.

Documentation: All studies of oak ecology or physiology rely upon correct identification and documentation of the tree not only to species, but also to the exact locality where it was collected. Equally important are records of taxonomy and provenance for trees that originated from cultivation, from other arboreta, or as progeny of other trees within the arboretum. The worth of tree collections becomes greater with additional resources such as deposition of representative specimens in herbaria (as would be useful for comparison to other oak specimens by taxonomists).

Taxonomic Completeness: For many questions about the evolution of oaks, it is beneficial to have a fairly complete sample of species from a given taxonomic section of *Quercus* or from a given geographic region. It would be very easy for evolutionary biologists to make erroneous conclusions about the factors that contribute to the evolution of certain traits if they are only looking at a small portion of the diversity of species within the group that they care about. Oak collections that are most useful include not only a large sampling of taxa, but also contain multiple exemplars of individuals throughout the range of each species. Our concept of a species relies upon comparisons (either genetic or morphological) of individuals that occur naturally in multiple geographic regions of that species. If a taxonomist were to compare only one exemplar of each species, it would be easy to suspect that oak species were really more different from each other than may be true in natural populations, as this comparison ignores variation within those species. Accomplishing a robust sampling of oak species is balanced by obvious costs of maintaining trees from diverse taxa. It is impossible to cultivate most species of oaks at any given arboretum based on the local climate and soil. Moreover, simply having the space to maintain a complete sampling of any large group of oaks would be a challenge for any arboretum.

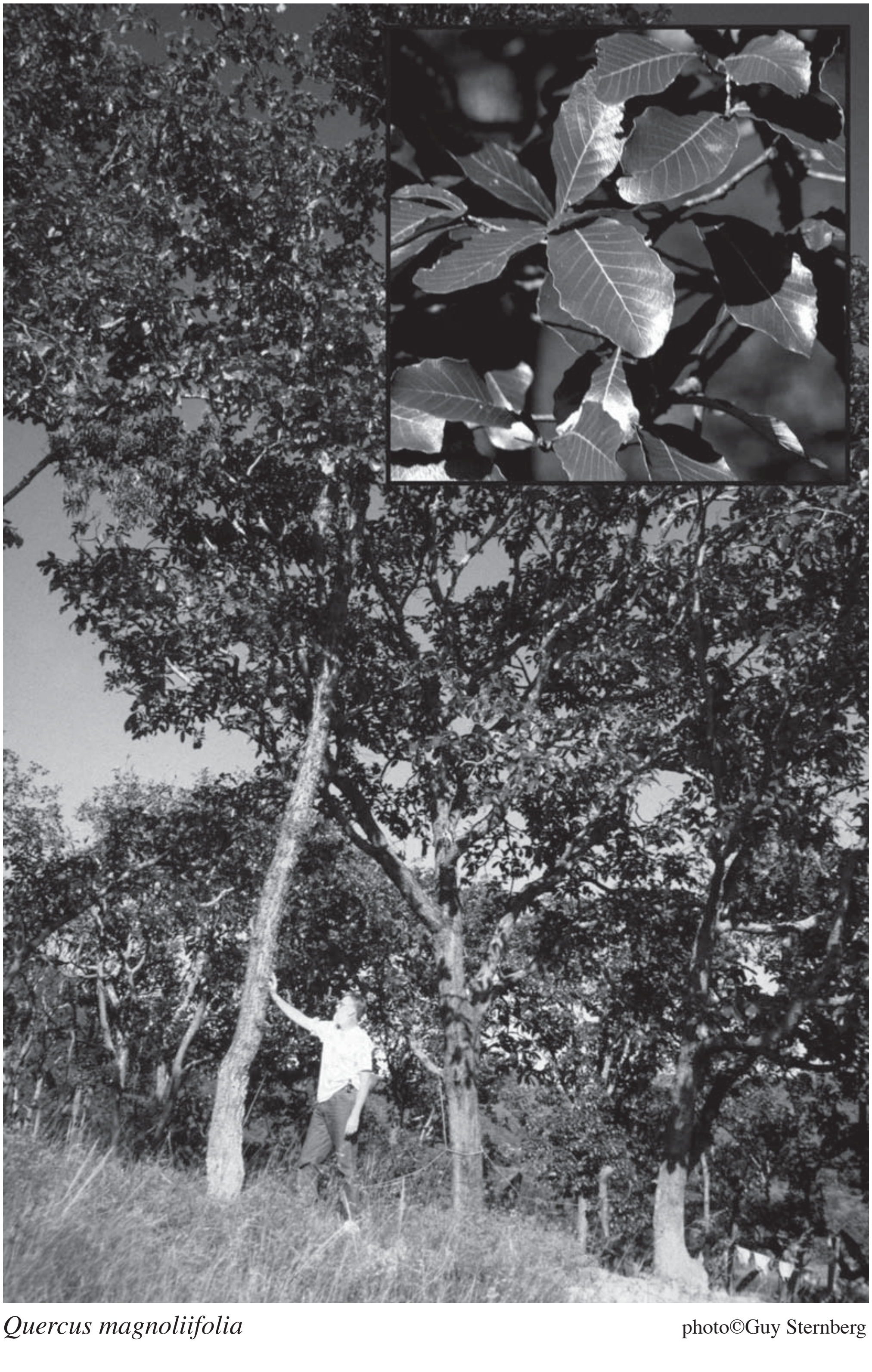
Aspects of a "Common Garden": Common garden experiments have been useful tools used by ecologists for over a century. When we look at the variation between individuals, populations, or species in their native habitat, we confound the effects of the different environments and the effects of inherent, genetic differences between those groups. A simple example might be comparing the leaf size of two oak species, one which grows in a xeric, sunny habitat and another in a mesic, shaded environment. We might see that the xeric, full-sun oak has smaller leaves than that species that grows in a wetter, shadier environment, but we also know that trees can alter their leaf size to adapt to different shade conditions. By simply growing plants in a common environment, we can more easily attribute differences in plant physiologies, morphologies, or ecologies, to genetic differences between individuals. Foresters (such as at the USDA Hardwood Tree Improvement and Regeneration Center) have planted true common gardens of oaks and other tree species with the goal determining the genetic basis of various tree traits. Arboreta provide a somewhat impromptu common garden of multiple oak species, and biologists do use them as such. There are potential pitfalls to this though. In a true common garden, plants are randomized throughout the garden such that there is no particular order to the trees (i.e. in an oak common garden there would be no "red oaks" section, "Eurasian natives" section, or unique stand of *Q. robur*). Again, designing an arboretum to fit strictly to the idea of a common garden would be useful to scientists that wanted to compare oak species, but it would also likely detract from the recreational uses of that arboretum.

Allowing ecology to happen: Despite being managed environments, there are many interesting ecological interactions going on in arboreta. Insects feed on the trees, mycorrhizae colonize roots, and squirrels eat the acorns. My personal research has explored many of these interactions within various arboreta in order to understand how native animals utilize different non-native plants. As many species of oaks have been planted world-wide, especially in arboreta, they provide an ideal setting to understand these novel interactions (Pearse and Hipp 2009). How do insects in California deal with the chemical defenses of oaks that evolved in Mexico? How do birds that eat small acorns on oaks in their native range learn to deal with monstrous *Q. macrocarpa* or *Q. castaneifolia* acorns? In order to be able to observe these interactions, it is necessary for the non-native tree to be in semi-natural setting. If we were to remove all of the acorn-eating birds or regularly apply pesticides to kill insects, it would be impossible to observe these interactions. Maintaining some degree of natural habitat within an arboretum can be useful in understanding the ecology of different oaks. Again, there are obvious trade-offs to doing this. If an insect outbreak occurs that could jeopardize the oak collection, it would quickly become desirable to mitigate the loss of the trees at the expense of the local insects.

Arboreta have the capacity to fulfill many purposes. Even different research biologists asking different questions about oaks will be interested in different aspects of arboreta. As a researcher that often uses arboreta as a scientific resource, I felt it may be helpful for arboretum directors and stewards to have a short list of attributes of arboreta that make them more or less useful as a scientific resource, such that they can balance those attributes with other uses such as recreation.

Griswold, E. 2009. Conseving Oaks in North American Plant Collections: A Collaborative Approach. International Oaks 20:35-42.

Pearse, I. S. and A. L. Hipp. 2009. Phylogenetic and trait similarity to a native species predict herbivory on non-native oaks. Proceedings of the National Academy of Sciences of the United States of America in press.



Quercus magnoliifolia photo©Guy Sternberg

Phenology and Gene Expression in *Quercus magnoliifolia* and *Q. resinosa* in an Altitudinal Gradient on the Volcano of Tequila, Jalisco, Mexico and Its Relation to Climate Change

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Growth and development of plants typically occur in the context of a stationary life. Therefore plants have evolved mechanisms to survive adverse conditions for growth. Tree species have adapted to local climate by evolving certain phenological characteristics. Phenology is important in the context of climate change and also determines the ranges of species. To predict likely responses of trees to global climate change we studied the phenology of *Q. magnoliifolia* and *Q. resinosa* in an altitudinal gradient (1450-2110 m) on the volcano of Tequila, Jalisco, Mexico using a scale of leaf development with values from 0 (dormant buds) to 5 (developed leaves). Environmental characteristics were recorded *in situ*. We found differences in the pattern and duration of leaf development. Phenological differences were associated with temperature, precipitation, and relative humidity. We also determined interspecific phenological differences and variation in phenology between the two years studied. The differential expression of seven candidate genes relevant in the signaling pathways for development in oaks was compared for the five stages of leaf development. These results, combined with others obtained by our working group, can help predict likely responses of trees to global climate change.

Quercus resinosa photo©Guy Sternberg

Quercus magnoliifolia photo©Guy Sternberg

Quercus resinosa photo©Guy Sternberg

Leaf Fluctuating Asymmetry Increases with Hybridization and Introgression between *Quercus magnoliifolia* and *Quercus resinosa* (Fagaceae) through an Altitudinal Gradient in Mexico

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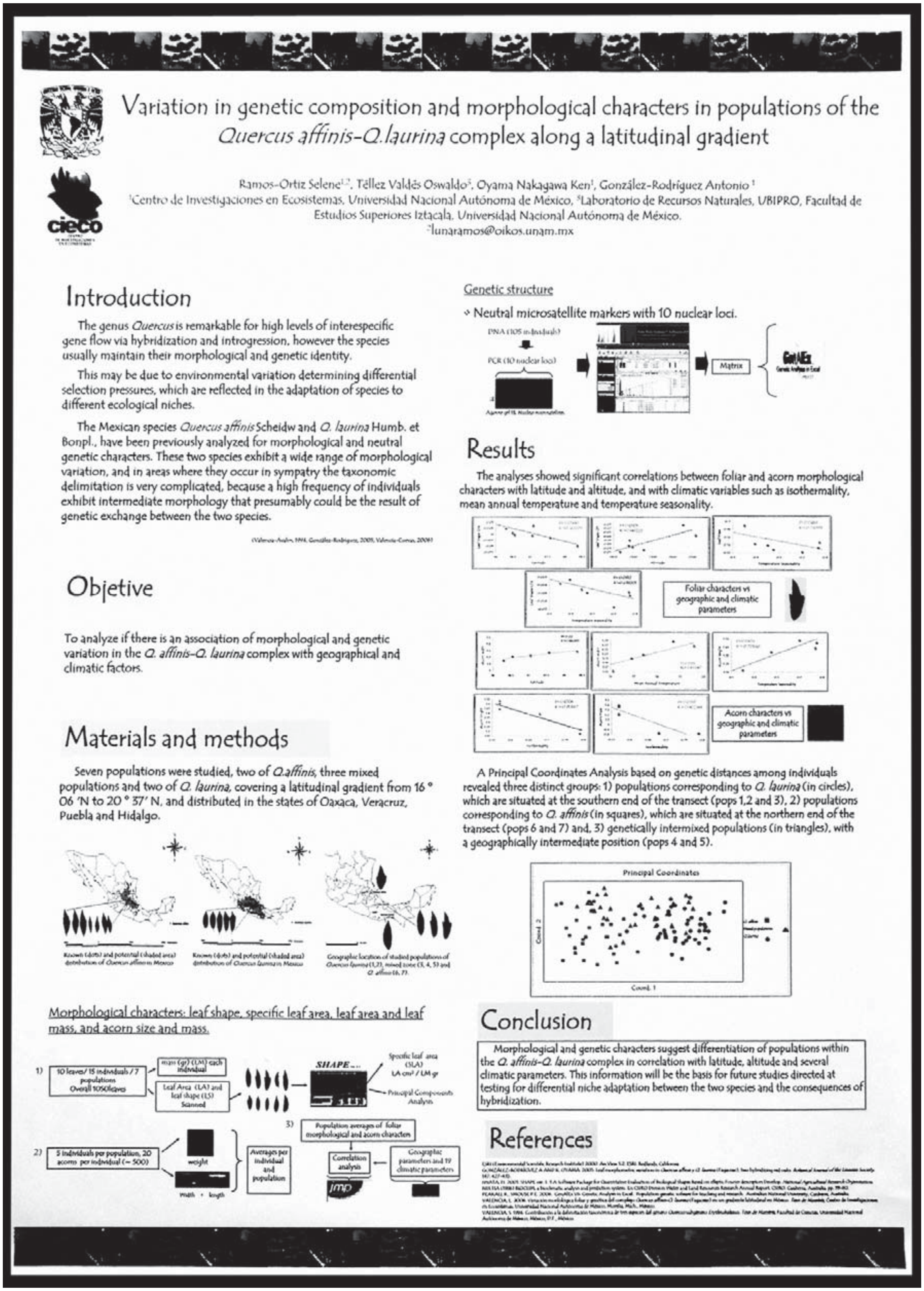
We examined the hypotheses that hybridization increases the level of developmental instability between *Q. magnoliifolia* and *Q. resinosa* at the Tequila volcano with morphological evidence and microsatellite marker data followed by Bayesian clustering analyses using the Structure program. Optimal thresholds for genetic assignment of pure, hybrid and backcrossed individuals were assessed using simulations. We found high leaf morphological differentiation between *Q. magnoliifolia* and *Q. resinosa* and a continuum of variation in leaf morphology in the individuals of the Tequila. Leaf-shape fluctuating asymmetry (FA) was higher in the hybrids and backcrosses than in pure species. The threshold q-value of $<$ 0.90 for *Q. magnoliifolia* and $q > 0.10$ for *Q. resinosa* allows separating pure species from F1 hybrids (q- >0.41 to <0.59) and backcrosses of *Q. magnoliifolia* (q > 0.90 to 0.60) and backcrosses of *Q. resinosa* (<0.10 to 0.40). Simulation results showed that the genetic classes of pure and backcrossed individuals detected with Structure were reconstructed with good efficiency and accuracy, with some problems identifying hybrid F1 individuals correctly. Our genetic and morphological results showed that *Q. magnoliifolia* and *Q. resinosa* are two different lineages that overlapped on the Tequila volcano forming a hybrid zone with secondary contact, and the higher levels of FA found in hybrids and backcrossed individuals, compared to pure species, suggest that hybridization process involved the disruption of co-adapted gene complexes characteristic of each parental species.


Variation in genetic composition and morphological characters in populations of the Quercus affinis-Q.laurina complex along a latitudinal gradient
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Introduction
The genus Quercus is remarkable for high levels of interespecific gene flow via hybridization and introgression, however the species usually maintain their morphological and genetic identity.
This may be due to environmental variation determining differential selection pressures, which are reflected in the adaptation of species to different ecological niches.
The Mexican species Quercus affinis Scheidw and Q. laurina Humb. et Bonpl., have been previously analyzed for morphological and neutral genetic characters. These two species exhibit a wide range of morphological variation, and in areas where they occur in sympatry the taxonomic delimitation is very complicated, because a high frequency of individuals exhibit intermediate morphology that presumably could be the result of genetic exchange between the two species.
Objetive
To analyze if there is an association of morphological and genetic variation in the Q. affinis-Q. laurina complex with geographical and climatic factors.
Materials and methods
Seven populations were studied, two of Q.affinis, three mixed populations and two of Q. laurina, covering a latitudinal gradient from 16 ° 06 'N to 20 ° 37' N, and distributed in the states of Oaxaca, Veracruz, Puebla and Hidalgo.
Morphological characters: leaf shape, specific leaf area, leaf area and leaf mass, and acorn size and mass.
10 leaves/ 15 individuals / 7 populations Overall 1050leaves
Leaf Area (LA) and leaf shape (LS) Scanned
SHAPE
Principal Components Analysis
5 individuals per population, 20 acorns per individual (~ 500)
weight
Averages per individual and population
Population averages of foliar morphological and acorn characters
Correlation analysis
Geographic parameters and 19 climatic parameters
jmp
Genetic structure
Neutral microsatellite markers with 10 nuclear loci.
PCR (10 nuclear loci)
Matrix
Results
The analyses showed significant correlations between foliar and acorn morphological characters with latitude and altitude, and with climatic variables such as isothermality, mean annual temperature and temperature seasonality.
Foliar characters vs geographic and climatic parameters
Acorn characters vs geographic and climatic parameters
A Principal Coordinates Analysis based on genetic distances among individuals revealed three distinct groups: 1) populations corresponding to Q. laurina (in circles), which are situated at the southern end of the transect (pops 1,2 and 3), 2) populations corresponding to Q. affinis (in squares), which are situated at the northern end of the transect (pops 6 and 7) and, 3) genetically intermixed populations (in triangles), with a geographically intermediate position (pops 4 and 5).
Principal Coordinates
Coord. 1
Coord. 2
Conclusion
Morphological and genetic characters suggest differentiation of populations within the Q. affinis-Q. laurina complex in correlation with latitude, altitude and several climatic parameters. This information will be the basis for future studies directed at testing for differential niche adaptation between the two species and the consequences of hybridization.
References

Variation in Genetic Composition and Morphological Characters in Populations of the *Quercus affinis-Q. laurina* Complex along a Latitudinal Gradient

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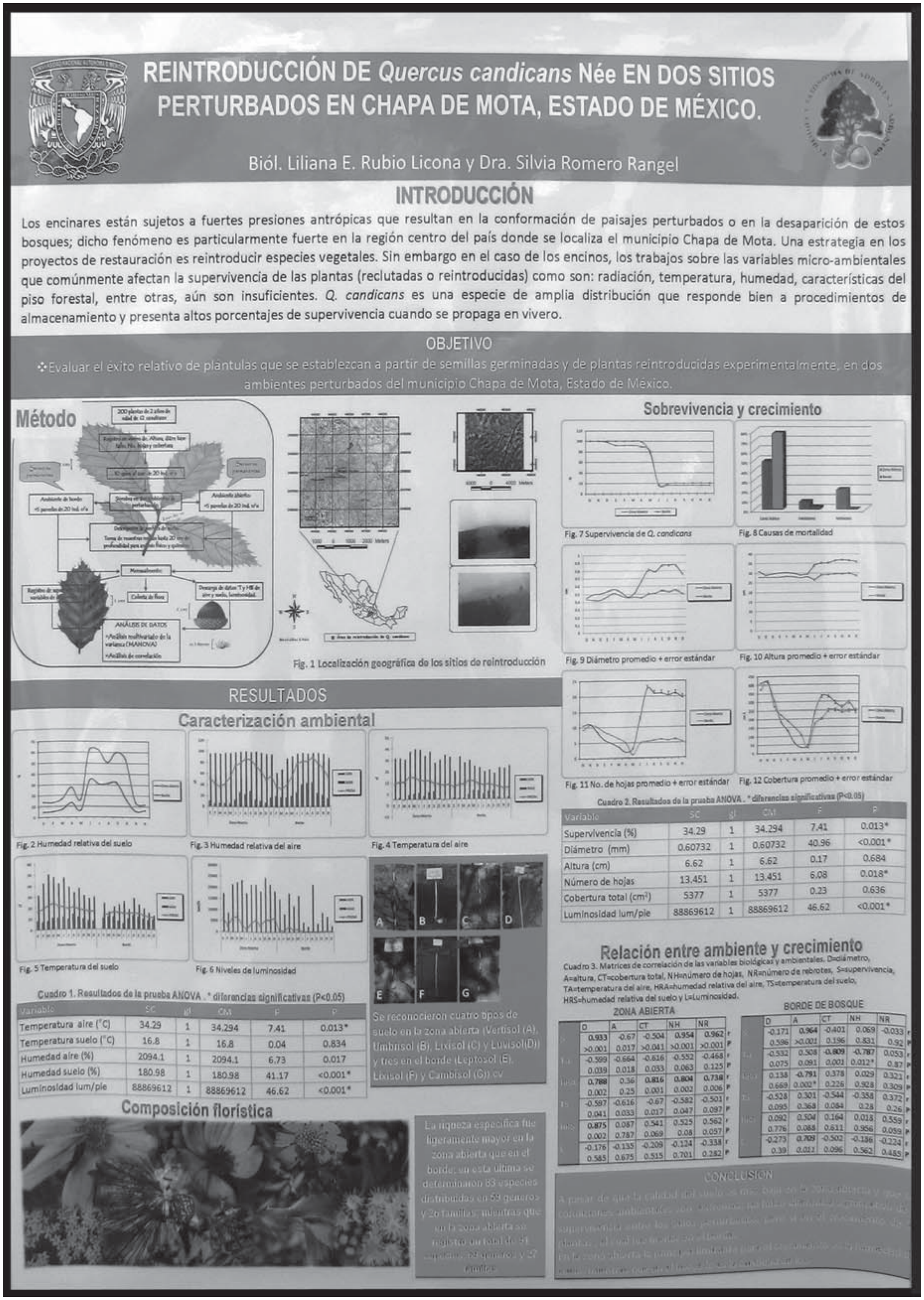
The genus *Quercus* is remarkable for high levels of interspecific gene flow via hybridization and introgression. However, the species usually maintain their morphological and genetic identity. This may be due to environmental variation determining differential selection pressures, which are reflected in the adaptation of species to different ecological niches. To understand the variation in morphological and genetic characters in a complex of Mexican red oaks formed by *Quercus affinis* and *Q. laurina*, foliar morphological characters (leaf shape, specific leaf area, leaf area, and mass) and seeds (mass and size) were correlated with distribution and climatic parameters. The genetic structure was determined using neutral microsatellite markers, with 10 nuclear and seven chloroplast loci. The morphological analysis showed a significant correlation between mass and size of seeds and foliar morphological characters like leaf shape and mass with latitude and altitude in addition to environmental variables such as isothermality, mean annual temperature, temperature seasonality, and temperature annual range. The results provide a basis for further studies on the ecophysiological and genetic variation among these two species.

Quercus affinis photo©Guy Sternberg

Quercus laurina photo©Guy Sternberg


REINTRODUCCIÓN DE Quercus candicans Née EN DOS SITIOS PERTURBADOS EN CHAPA DE MOTA, ESTADO DE MÉXICO.
Biól. Liliana E. Rubio Licona y Dra. Silvia Romero Rangel
INTRODUCCIÓN
Los encinares están sujetos a fuertes presiones antrópicas que resultan en la conformación de paisajes perturbados o en la desaparición de estos bosques; dicho fenómeno es particularmente fuerte en la región centro del país donde se localiza el municipio Chapa de Mota. Una estrategia en los proyectos de restauración es reintroducir especies vegetales. Sin embargo en el caso de los encinos, los trabajos sobre las variables micro-ambientales que comúnmente afectan la supervivencia de las plantas (reclutadas o reintroducidas) como son: radiación, temperatura, humedad, características del piso forestal, entre otras, aún son insuficientes. Q. candicans es una especie de amplia distribución que responde bien a procedimientos de almacenamiento y presenta altos porcentajes de supervivencia cuando se propaga en vivero.
OBJETIVO
Evaluar el éxito relativo de plantulas que se establezcan a partir de semillas germinadas y de plantas reintroducidas experimentalmente, en dos ambientes perturbados del municipio Chapa de Mota, Estado de México.
Método
Fig. 1 Localización geográfica de los sitios de reintroducción
Sobrevivencia y crecimiento
Fig. 7 Supervivencia de Q. candicans
Fig. 8 Causas de mortalidad
Fig. 9 Diámetro promedio + error estándar
Fig. 10 Altura promedio + error estándar
Fig. 11 No. de hojas promedio + error estándar
Fig. 12 Cobertura promedio + error estándar
Cuadro 2. Resultados de la prueba ANOVA . * diferencias significativas (P<0.05)
Variable | SC | gl | CM | F | P
Supervivencia (%) | 34.29 | 1 | 34.294 | 7.41 | 0.013*
Diámetro (mm) | 0.60732 | 1 | 0.60732 | 40.96 | <0.001*
Altura (cm) | 6.62 | 1 | 6.62 | 0.17 | 0.684
Número de hojas | 13.451 | 1 | 13.451 | 6.08 | 0.018*
Cobertura total (cm2) | 5377 | 1 | 5377 | 0.23 | 0.636
Luminosidad lum/pie | 88869612 | 1 | 88869612 | 46.62 | <0.001*
RESULTADOS
Caracterización ambiental
Fig. 2 Humedad relativa del suelo
Fig. 3 Humedad relativa del aire
Fig. 4 Temperatura del aire
Fig. 5 Temperatura del suelo
Fig. 6 Niveles de luminosidad
Cuadro 1. Resultados de la prueba ANOVA . * diferencias significativas (P<0.05)
Variable | SC | gl | CM | F | P
Temperatura aire (°C) | 34.29 | 1 | 34.294 | 7.41 | 0.013*
Temperatura suelo (°C) | 16.8 | 1 | 16.8 | 0.04 | 0.834
Humedad aire (%) | 2094.1 | 1 | 2094.1 | 6.73 | 0.017
Humedad suelo (%) | 180.98 | 1 | 180.98 | 41.17 | <0.001*
Luminosidad lum/pie | 88869612 | 1 | 88869612 | 46.62 | <0.001*
A B C D E F G
Se reconocieron cuatro tipos de suelo en la zona abierta (Vertisol (A), Umbrisol (B), Lixisol (C) y Luvisol(D)) y tres en el borde (Leptosol (E), Lixisol (F) y Cambisol (G)) cv
Composición florística
La riqueza especifica fue ligeramente mayor en la zona abierta que en el
Relación entre ambiente y crecimiento
Cuadro 3. Matrices de correlación de las variables biológicas y ambientales. D=diámetro, A=altura, CT=cobertura total, NH=número de hojas, NR=número de rebrotes, S=supervivencia, TA=temperatura del aire, HRA=humedad relativa del aire, TS=temperatura del suelo, HRS=humedad relativa del suelo y L=Luminosidad.
ZONA ABIERTA
BORDE DE BOSQUE
CONCLUSIÓN

Relation Between Perturbation Degree and Success in Reintroduction of *Quercus candicans* Née (*Fagaceae*)

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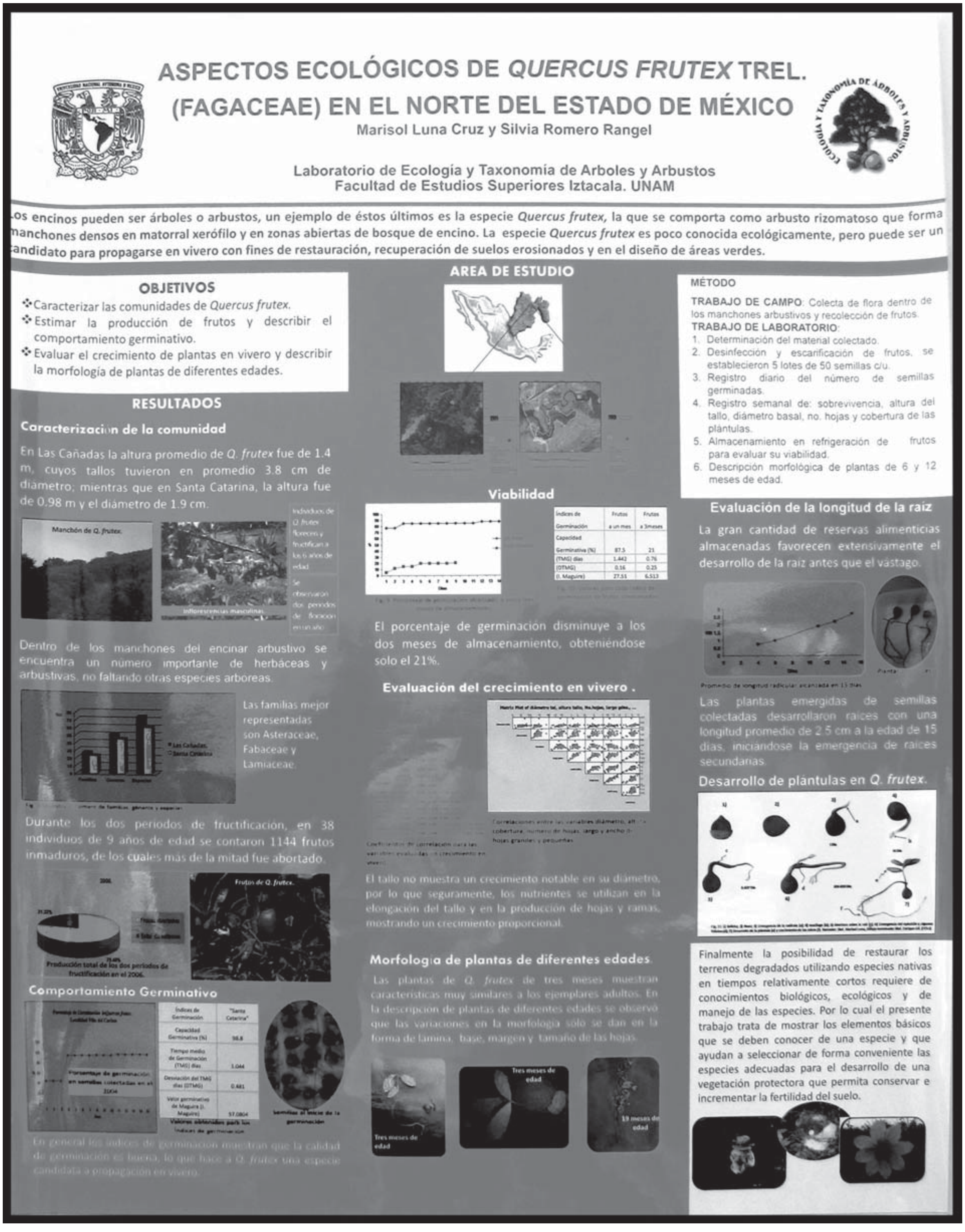
Our study was held in Chapa de Mota municipality in the State of Mexico. Our objective was to evaluate seedling performance in germinated seeds and reintroduced plants in two disturbed environments. Light, temperature (°T), and air/soil relative humidity (H%) were evaluated. Edafic characteristics and floristic composition also were evaluated. The growth and survival of plants of *Quercus candicans* were related to the described environmental conditions. No significant differences were found in the survival ($p<0.05$), that was less in open areas (16%) than on the edges of woodland. Young seedlings showed differences in diameter, height, and buds; the contrasting microenvironmental conditions were L and T of air and soil. The correlation of growth variables with environmental ones was distinct in the two environments. Species and soil characteristics parallel disturbance characteristics; the latter can define which variables will affect the establishment of *Quercus* seedlings. In the same way it could indicate which improvements could be done to the techniques used with the purpose of increasing survival in the plantations, or what strategies to use according to site characteristics. This could optimize resources in restoration projects in *Quercus* forests, the species diversity of which is very important in Mexico.


ASPECTOS ECOLÓGICOS DE QUERCUS FRUTEX TREL.
(FAGACEAE) EN EL NORTE DEL ESTADO DE MÉXICO
Marisol Luna Cruz y Silvia Romero Rangel
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ECOLOGÍA Y TAXONOMÍA DE ÁRBOLES Y ARBUSTOS
Los encinos pueden ser árboles o arbustos, un ejemplo de éstos últimos es la especie Quercus frutex, la que se comporta como arbusto rizomatoso que forma manchones densos en matorral xerófilo y en zonas abiertas de bosque de encino. La especie Quercus frutex es poco conocida ecológicamente, pero puede ser un candidato para propagarse en vivero con fines de restauración, recuperación de suelos erosionados y en el diseño de áreas verdes.
OBJETIVOS
Caracterizar las comunidades de Quercus frutex.
Estimar la producción de frutos y describir el comportamiento germinativo.
Evaluar el crecimiento de plantas en vivero y describir la morfología de plantas de diferentes edades.
RESULTADOS
Caracterización de la comunidad
En Las Cañadas la altura promedio de Q. frutex fue de 1.4 m, cuyos tallos tuvieron en promedio 3.8 cm de diámetro; mientras que en Santa Catarina, la altura fue de 0.98 m y el diámetro de 1.9 cm.
Manchón de Q. frutex.
Inflorescencias masculinas
Dentro de los manchones del encinar arbustivo se encuentra un número importante de herbáceas y arbustivas, no faltando otras especies arboreas.
Las familias mejor representadas son Asteraceae, Fabaceae y Lamiaceae.
Durante los dos periodos de fructificación, en 38 individuos de 9 años de edad se contaron 1144 frutos inmaduros, de los cuales más de la mitad fue abortado.
Frutos de Q. frutex.
Producción total de los dos periodos de fructificación en el 2006.
Comportamiento Germinativo
Valores obtenidos para los índices de germinación
En general los índices de germinación muestran que la calidad de germinación es buena, lo que hace a Q. frutex una especie candidata a propagación en vivero.
AREA DE ESTUDIO
Viabilidad
El porcentaje de germinación disminuye a los dos meses de almacenamiento, obteniéndose solo el 21%.
Evaluación del crecimiento en vivero.
El tallo no muestra un crecimiento notable en su diámetro, por lo que seguramente, los nutrientes se utilizan en la elongación del tallo y en la producción de hojas y ramas, mostrando un crecimiento proporcional.
Morfología de plantas de diferentes edades.
Las plantas de Q. frutex de tres meses muestran características muy similares a los ejemplares adultos. En la descripción de plantas de diferentes edades se observó que las variaciones en la morfología sólo se dan en la forma de lamina, base, margen y tamaño de las hojas.
Tres meses de edad
Tres meses de edad
19 meses de edad
MÉTODO
TRABAJO DE CAMPO: Colecta de flora dentro de los manchones arbustivos y recolección de frutos.
TRABAJO DE LABORATORIO:
1. Determinación del material colectado.
2. Desinfección y escarificación de frutos, se establecieron 5 lotes de 50 semillas c/u.
3. Registro diario del número de semillas germinadas.
4. Registro semanal de: sobrevivencia, altura del tallo, diámetro basal, no. hojas y cobertura de las plántulas.
5. Almacenamiento en refrigeración de frutos para evaluar su viabilidad.
6. Descripción morfológica de plantas de 6 y 12 meses de edad.
Evaluación de la longitud de la raíz
La gran cantidad de reservas alimenticias almacenadas favorecen extensivamente el desarrollo de la raíz antes que el vástago.
Las plantas emergidas de semillas colectadas desarrollaron raíces con una longitud promedio de 2.5 cm a la edad de 15 días, iniciándose la emergencia de raíces secundarias.
Desarrollo de plántulas en Q. frutex.
Finalmente la posibilidad de restaurar los terrenos degradados utilizando especies nativas en tiempos relativamente cortos requiere de conocimientos biológicos, ecológicos y de manejo de las especies. Por lo cual el presente trabajo trata de mostrar los elementos básicos que se deben conocer de una especie y que ayudan a seleccionar de forma conveniente las especies adecuadas para el desarrollo de una vegetación protectora que permita conservar e incrementar la fertilidad del suelo.

Ecological Aspects of *Quercus frutex* Trel. (Fagaceae) in Three Localities in the State of Mexico

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This work contributes to the ecological knowledge of the communities of *Quercus frutex* through an evaluation of production and weight of fruits, germination behavior, viability, growth in the nursery and in the field, and morphological and phenological description. Fruit collection and phenological registration were developed in Tepotzotlan and Villa del Carbon. Fruits were stratified for establishment and germination index was measured.

A correlation between diameter, stem height, leaf number and coverage, and fruit weight was analyzed, and phenology and morphology of young seedlings and fruit production also were analyzed. Fruit production totalled 1144 fruits of which 78.5% were aborted and 21.5% ripened. June and August were the months with most fruit production and the highest degree of maturity.

The germination capacity was 98.8% and the germination value was 57.0804. Fruits stored for one month showed 87.5% germination and an additional 21% at three months. The stems did not have a noticeable growth in diameter. The morphological variations occur in the lamina, base, margin, and leaf sizes. Two periods of flowering and fruiting were observed.

ASPECTOS ECOLÓGICOS DE *Quercus obtusata* Humb. & Bonpl. y *Quercus castanea* Née EN EL ESTADO DE MÉXICO

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INTRODUCCIÓN

En el Estado de México hay 23 especies del género *Quercus* (Romero et al., 2000), entre las cuales figuran *Quercus obtusata* y *Quercus castanea* que co-habitan en bosques de encino y mixtos de pino-encino. A pesar de la importancia económica y ecológica de estas especies se desconocen aspectos básicos de su biología **como** el comportamiento germinativo y la sobrevivencia de sus plántulas. Además hay pocos datos sobre las especies que conviven naturalmente con dichas especies de encino.

OBJETIVOS

- Caracterizar florística y estructuralmente dos comunidades de bosque en el Estado de México.
- Caracterizar el comportamiento germinativo y evaluar la viabilidad de semillas de *Q. obtusta* y *Q. castanea*.
- Describir el crecimiento en vivero de estas dos especies, así como la morfología de sus plántulas.

MÉTODO

TRABAJO DE CAMPO:

1.En cada localidad: establecimiento al azar de 5 cuadros de 200 m2.
2.En cada cuadro: registro de DAP, altura y cobertura de árboles; asi como colecta de árboles, arbustos y herbáceas.
3.Recolección de frutos de *Q. obtusata* y *Q. castanea*.

TRABAJO DE LABORATORIO:

1.Determinación taxonómica del material colectado.
2.Desinfección (NaOCl al 15%) y escarificación mecánica.
3.De c/especie se establecieron 5 lotes de 50 semillas c/u.
4.Registro diario del No. semillas germinadas.
5.Siembra en suelo de las semillas germinadas.
6.Registro semanal de sobrevivencia, altura del tallo, diámetro basal, No. Hojas y cobertura de las plántulas.
7.Almacenamiento de frutos en refrigeración (5-7 °C), c/ 3 meses se extrajo una muestra de 50 semillas para evaluar la viabilidad.
8.Descripción morfológica de plantas de 6 y 12 meses de edad.

RESULTADOS

Caracterización estructural y riqueza florística de las comunidades

Cuadro 1. Atributos del estrato arbóreo en la comunidad de bosque en Puentecillas.

Especie	No Ind.	Densidad (%)	Frecuencia (%)	Área basal (m2)	AB (%)	Cobertura (%)	VIR (D%+F%+AB%)
Q. obtusata	8	8.333	19.2	4208.968	10.114	6.720	37.679
Q. crassipes	8	8.333	15.4	8013.052	19.256	37.511	42.974
Q. crasifolia	5	5.208	7.7	6690.356	16.077	5.275	28.979
Q. candicans	3	3.125	7.7	7834.156	18.826	22.591	29.644
Q. dysophylla	17	17.708	19.2	4109.185	9.874	14.460	46.814
P. leiophylla	50	52.083	15.4	9631.755	23.146	12.763	90.614
C. lusitanica	1	1.042	3.8	7.068	0.016	0.046	4.905
A. jorullensis	2	2.083	3.8	1103.487	2.651	0.601	8.581
A. tesellata	1	1.042	3.8	7.068	0.016	0.002	4.905
P. serotina	1	1.042	3.8	7.068	0.016	0.032	4.905
TOTAL:	96	100.000	100.000	41612.16[illegible]	100.000	100.000	300.000

Cuadro 2. Atributos del estrato arbóreo en la comunidad de bosque en Loma de Cuevas.

Especie	No Ind.	Densidad (%)	Frecuencia (%)	Área basal (m2)	AB (%)	Cobertura (%)	VIR (D%+F%+AB%)
Q. castanea	28	36.363	41.666	36606.205	49.551	40.018	127.581
Q. obtusata	45	58.441	41.666	37217.342	50.378	59.963	150.486
P. serotina	4	5.194	16.666	51.836	0.070	0.018	21.931
TOTAL:	77	100.000	100.000	73875.383	100.000	100.000	300.000

La riqueza florística del bosque en Puentecillas, Nicolás Romero ; estuvo compuesta por 52 especies, 40 géneros y 28 familias; las más representativas del estrato arbustivo fueron: ***Senecio roldana*** y ***Monina ciliolata***. La del bosque de encino en Loma de Cuevas, Villa del Carbón, está constituida por 67 especies, 55 géneros y 31 familias; en el estrato arbustivo ***Eupatorium petiolare*** y ***Salvia mexicana*** fueron las especies mejor representadas.

Sobrevivencia y crecimiento de las especies de encino

En la fase de vivero se establecieron 232 plántulas de *Q. obtusata* y 247 de *Q. castanea*. Del total sobrevivió el 13.79% de *Q. obtusata* y 64.4% de *Q. castanea*.

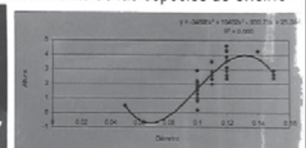

Fig. 6 Relación de variables altura-diámetro del tallo para *Q. obtusata*

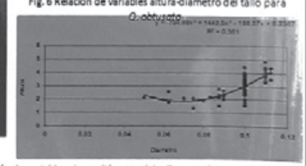

Fig. 7 Relación de variables altura-diámetro del tallo para *Q. castanea*

Comportamiento germinativo y viabilidad de *Q. obtusata* y *Q. castanea*

	Q. obtusata	Q. castanea
Frutos / Kg	354	738
Peso promedio de los frutos	3.99 gr	1.68 gr
Peso promedio de semillas	1.19 gr	0.789 gr
ÍNDICES DE GERMINACIÓN (Camacho y Morales, 1992)		
	Q. obtusata	Q. castanea
Capacidad germinativa (%)	92.80	98.80
Tiempo Medio de Germinación (días)	3.64	3.17
Desviación del TMG (días)	3.72	2.86
Índice de Maguire	23.87	26.04

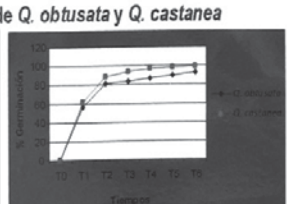

Fig. 1 Capacidad germinativa de las dos especies de encino a diferentes tiempos. (T0= día establecimiento, T1= día 3, T2=día 5, T3= día 7, T4= día 9, T5= día 11 y T6= día 13.

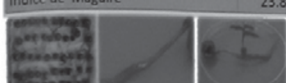

Fig. 2 Fases del desarrollo de plántulas de *Q. obtusata*

Fig. 3 Poliembrionía en *Q. obtusata*

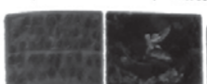

Fig. 4 Fases del desarrollo de plántulas de *Q. castanea*

Después de tres meses de almacenamiento las semillas de *Q. obtusata* perdieron su viabilidad (0% de germinación).

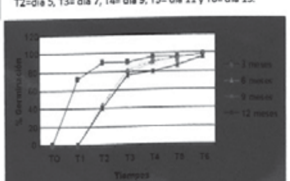

Fig. 5 Capacidad germinativa de *Q. castanea* a diferentes tiempos de almacenamiento en refrigeración.

Morfología de plantas

Las diferencias morfológicas entre las plantas de diferentes edades de *Q. obtusata* estuvieron en la **forma, ápice, base y color de las hojas;** los individuos de seis meses no presentaron **tricomas glandulares** que es un caracter diagnóstico que permiten reconocer a *Q. obtusata*. En las plantas de *Q. castanea* se encontraron diferencias en la **forma, ápice y base de las hojas así como en el número de dientes por lado de las hojas.**

Fig. 8 Plantas de 6 (B) y 12 (A) meses de edad de *Quercus obtusata*

Fig. 9 Plantas de 6 (B) y 12 (A) meses de edad de *Quercus castanea*

A Contribution to the Ecological Study of *Quercus obtusata* Bonpl. and *Quercus castanea* Née in Two Localities in the State of Mexico

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This is a contribution to the ecological knowledge of *Quercus obtusata* and *Quercus castanea* through study of their habitat, germination behavior, viability after storage, survival, and morphology. To study structure, five squares of 200m^2 in two localities were established. Canopy, height, and dbh were measured and specimens were collected. Fruits were collected and half of them were stored. Five batches for germination of 50 seeds were prepared. The growth was monitored in the laboratory and nursery. The viability of stratified seeds was determined and descriptions were made of young plants.

Both localities share 13 species, 19 genera and 16 families, Villa del Carbón being the zone with most floristic diversity. In Nicolás Romero *Pinus leiophylla* had the highest importance value, followed by *Q. dysophylla, Q. crassipes and Q. obtusata*. In Villa del Carbón, *Q. obtusata* had the highest value in importance, frequency, and coverage, followed by *Q. castanea* and *Prunus serotina*.

Germination was initiated in both species, reaching 92.8% for *Q. obtusata* and 98.8% for *Q. castanea*. Survival was 100% for *Q. obtusata* and 64.4% for *Q. castanea*. Viability was 100% for seeds of *Q. obtusata* and 64.4% for *Q. castanea*. The viability of *Q. obtusata* seeds was zero after 30 days of storage while *Q. castanea* was viable after 12 months. Morphological differences were found in

Quercus obtusata photo©Guy Sternberg

Quercus schottkyana (Xi Shan, Kunming) photo©Guy Sternberg

Acorn Production of *Quercus schottkyana*: an Endemic Evergreen Oak Species (subgenus *Cyclobalanopsis*) of Southwestern China

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Quercus schottkyana, belonging to oak subgenus *Cyclobalanopsis,* is one of the dominant trees in southwest China. It produces acorns annually. The acorns are important in the ecological system for the potential recruitment for the population as well as for food resources for insects and rodents. However, acorn production of this species is not well documented. In this study, we collected acorns of this species for three consecutive years (2006y-2008) at a site of c. 3850m altitude in Kunming, China. Weekly collections of acorns were used for determining the dry mass, moisture content, weevil (*Curculio* sp.) infestation rates, and germination. Results show the year 2006 to have been a mast year followed by two lean years. The peak time of weevil infestation was noticeable in the end of September and the beginning of October. Acorns dispersed after the beginning of October showed less infestation, greater weight, and better viability and might have the most important role for maintaining the oak population.

The Reponse of *Quercus* Section *Heterobalanus* (Golden Oaks) to the Himalayan Uplift

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Quercus section *Heterobalanus* is a natural group of oaks concentrated in SW China and the Himalaya, with 9 to 11 species. They are called golden oaks because of the back of leaves of most of them are covered by dense yellow hairs. One of the most outstanding features of the modern flora of the eastern Himalaya and Hengduan mountains is the preponderance of sclerophyllous oak forests.

These oaks are the main element in Himalayan ecosystem and play an important ecological role in terms of sheer abundance of standing biomass. In order to study the development, differentiation and distribution of *Quercus* section *Heterobalanus* in response to the uplift of the Himalaya, the hypothesis has been proposed that Quercus Section Heterobalanus originated in subtropical broad-leaf evergreen forests. After the uplift of the Hengduan mountains, whereby the climate became cold and dry, the environment ceased to favor most broad-leafed evergreen trees. However, oaks of section Heterobalanus, having obvious xerophytic characters such as dense hairs, thick cuticles, lignified epidermal cell walls and cuticles, and low stomatal density were preadapted to the environmental change and therefore became dominant in this area. This hypothesis has been documented by evidence from modern distribution, fossil history, genetic diversity and photosynthetic performance.

The Conservation and Population Increase of the Endangered Species, *Quercus sichourensis*

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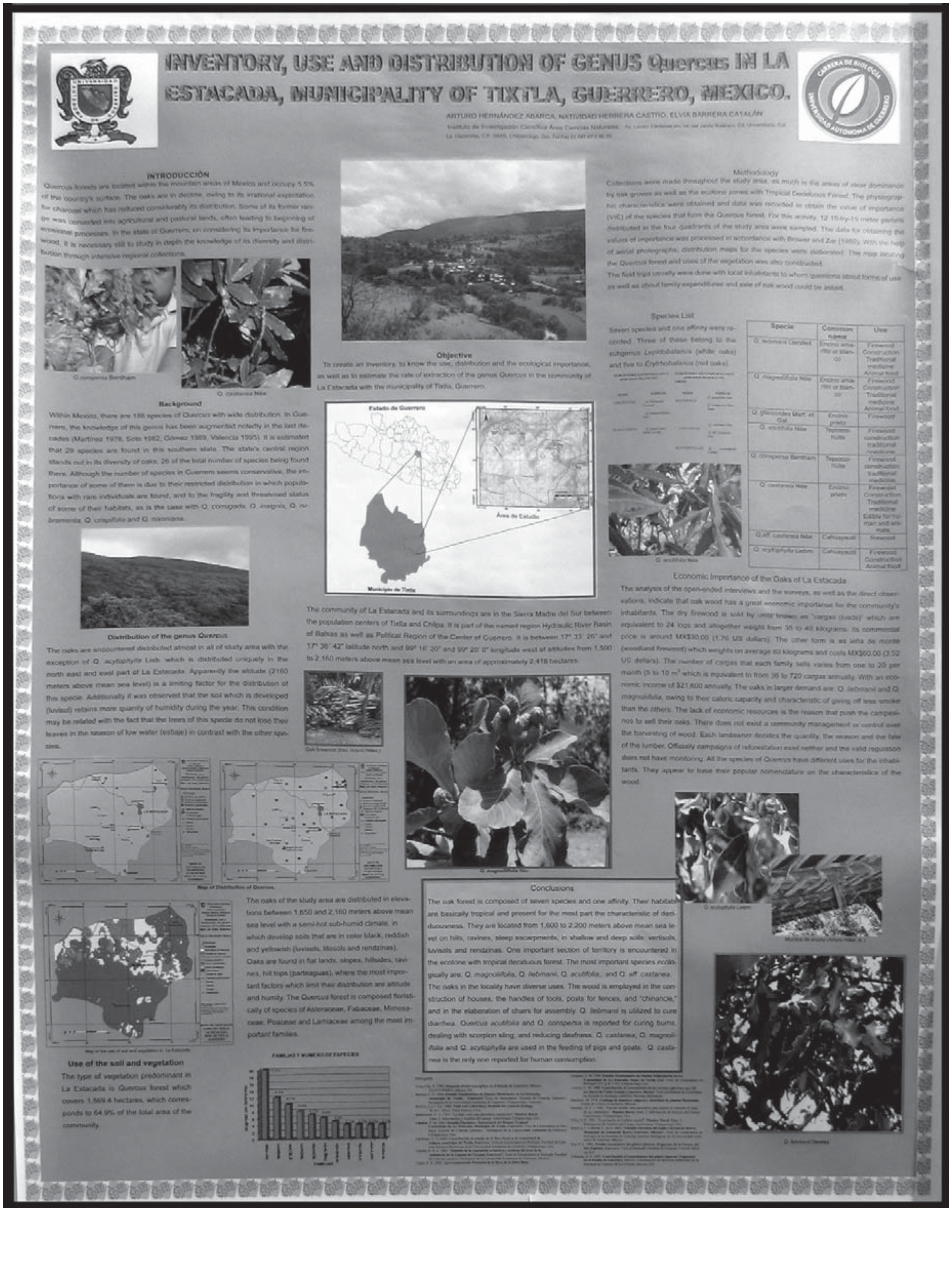
Quercus sichourensis (*Quercus*, *Fagaceae*) is an endangered species with only 5 adult individuals in Funing in Yunnan and Ceheng in Guizhou. It is also a key species in the broad leafed evergreen forest in limestone areas in SE Yunnan. The fruit with cupule has a diameter of 37.95±0.69 mm, presenting a normal distribution; the fruit weighed 25.93±1.18g; and the seed weighed 13.46±0.81g. The fruit had a moisture content of 46.7±0.3% at the time of natural dispersal. The pericarp of the fruit was permeable. Although the cupule can resist dessication, the fruits of *Quercus sichourensis* lost moisture rapidly. Fruits had moisture content less than 20% after 7 days' drying. Desiccation could obviously decrease their germination. The optimal temperatures for germinating *Q. sichourensis* fruits were 25°C and 30°C. Of the germination, 88-89.5% of the seedlings survived in the nursery planting. The dominant species of subgenus *Cyclobalanopsis* growing in the habitats of *Q. sichourensis* were also investigated. Fruits of these dominant species mature in the rainy season. The fruits of rare species *Q. sichourensis, Q. austroglauca, Q. camusiae,* and *Q. lobbii* mature at the end of the rainy season. This implies that the maturity of the fruits of subgenus *Cyclobalanopsis* are affected by the amount of precipitation. We currently have 300 seedlings growing in the nursery. To increase the number of individuals in the wild, and also to bolster the population of *Quercus sichourensis*, 50 seedlings have been replanted into their ancestral habitat.

Note from the editor:

Conservation efforts financed by the National Natural Science Fondation of China to help save *Quercus sichourensis* – considered to be critically endangered since the publication of the *Red List of Oaks* (Oldfield and Eastwood, Fauna and Flora International, Cambridge, UK, 2008) – received additional support in 2008 in the form of an International Oak Society grant of $1,000 plus $3,300 raised through private donations. Three IOS members (Diana Gardener, OR; Caroline Brown, CA; and Béatrice Chassé, FRANCE) plus one non-member (Alison Ramsdale, UK) are the contributors to this very successsful fund-raising campagne.


INVENTORY, USE AND DISTRIBUTION OF GENUS Quercus IN LA ESTACADA, MUNICIPALITY OF TIXTLA, GUERRERO, MEXICO.
ARTURO HERNÁNDEZ ABARCA, NATIVIDAD HERRERA CASTRO, ELVIA BARRERA CATALÁN
INTRODUCCIÓN
Objective
Background
Methodology
Species List
Specie
Common name
Use
Economic Importance of the Oaks of La Estacada
Distribution of the genus Quercus
Use of the soil and vegetation
Conclusions
The oak forest is composed of seven species and one affinity. Their habitats are basically tropical and present for the most part the characteristic of deciduousness. They are located from 1,600 to 2,200 meters above mean sea level on hills, ravines, steep escarpments, in shallow and deep soils: vertisols, luvisols and rendzinas. One important section of territory is encountered in the ecotone with tropical deciduous forest. The most important species ecologically are: Q. magnoliifolia, Q. liebmanii, Q. acutifolia, and Q. aff. castanea. The oaks in the locality have diverse uses. The wood is employed in the construction of houses, the handles of tools, posts for fences, and "chinancle," and in the elaboration of chairs for assembly. Q. liebmanii is utilized to cure diarrhea. Quercus acutifolia and Q. conspersa is reported for curing burns, dealing with scorpion sting, and reducing deafness. Q. castanea, Q. magnoliifolia and Q. acytophylla are used in the feeding of pigs and goats. Q. castanea is the only one reported for human consumption.

Inventory, Use and Distribution of the Genus *Quercus* in La Estacada, Municipio Tixtla, Guerrero

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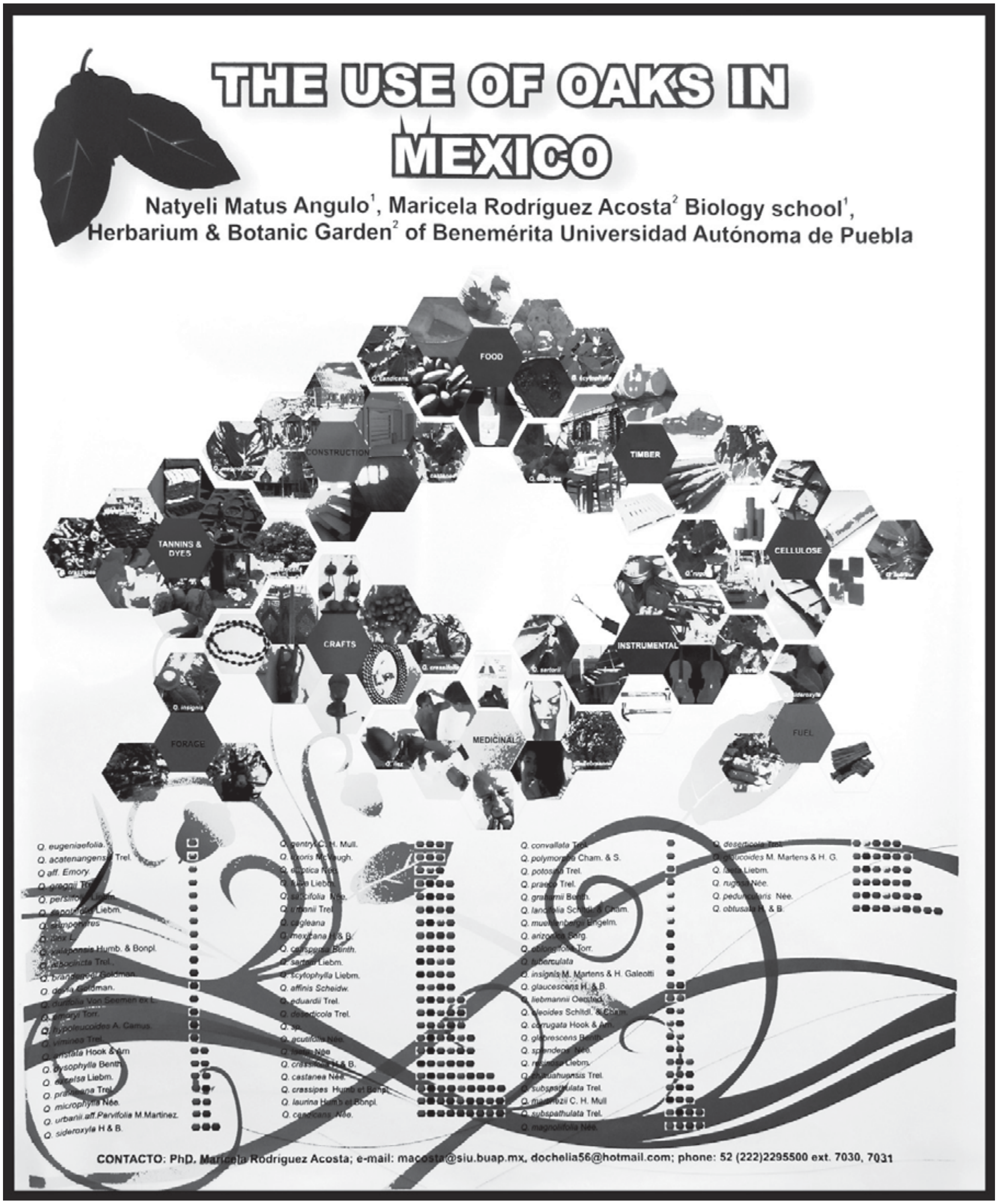
Mexico is one of the countries with the greatest diversity of oaks in the world and the state of Guerrero contributes significantly to this diversity. This paper provides information on the diversity and distribution of the genus *Quercus* in the community of La Estacada of the municipality of Tixtla in the state of Guerrero, Mexico. Botanic collections, analyses of trait distributions, field trips with local guides and ethnobotanical surveys were used to detail the ecological, economic and cultural aspects of oaks in the study area.

A floristic list of the species of the genus *Quercus* present in the study area, tables of statistical/ecological data and maps of vegetation, soil use as well as species distributions are included. Seven species and one affinity are reported, representing 28.6% of the species within the state and 66.7% within the municipality of Tixtla. The species with the most important ecological values are *Q. magnoliifolia* and *Q. liebmannii*. All species of *Quercus* have some use for the population. The most common is as a fuel with great commercial importance at the local and regional level, a use that contributes toward family income. Medicinal and food uses are reported for other species.

Quercus liebmannii photo©Guy Sternberg


THE USE OF OAKS IN MEXICO
Natyeli Matus Angulo[1], Maricela Rodríguez Acosta[2] Biology school[1],
Herbarium & Botanic Garden[2] of Benemérita Universidad Autónoma de Puebla
FOOD
CONSTRUCTION
TIMBER
TANNINS & DYES
CELLULOSE
CRAFTS
INSTRUMENTAL
FORAGE
MEDICINAL
FUEL
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The Use of Oaks in Mexico

***Natyeli Matus Angulo and **Maricela Rodríguez-Acosta**
* Escuela de Biología y ** Jardín botánico y herbario, Benemérita
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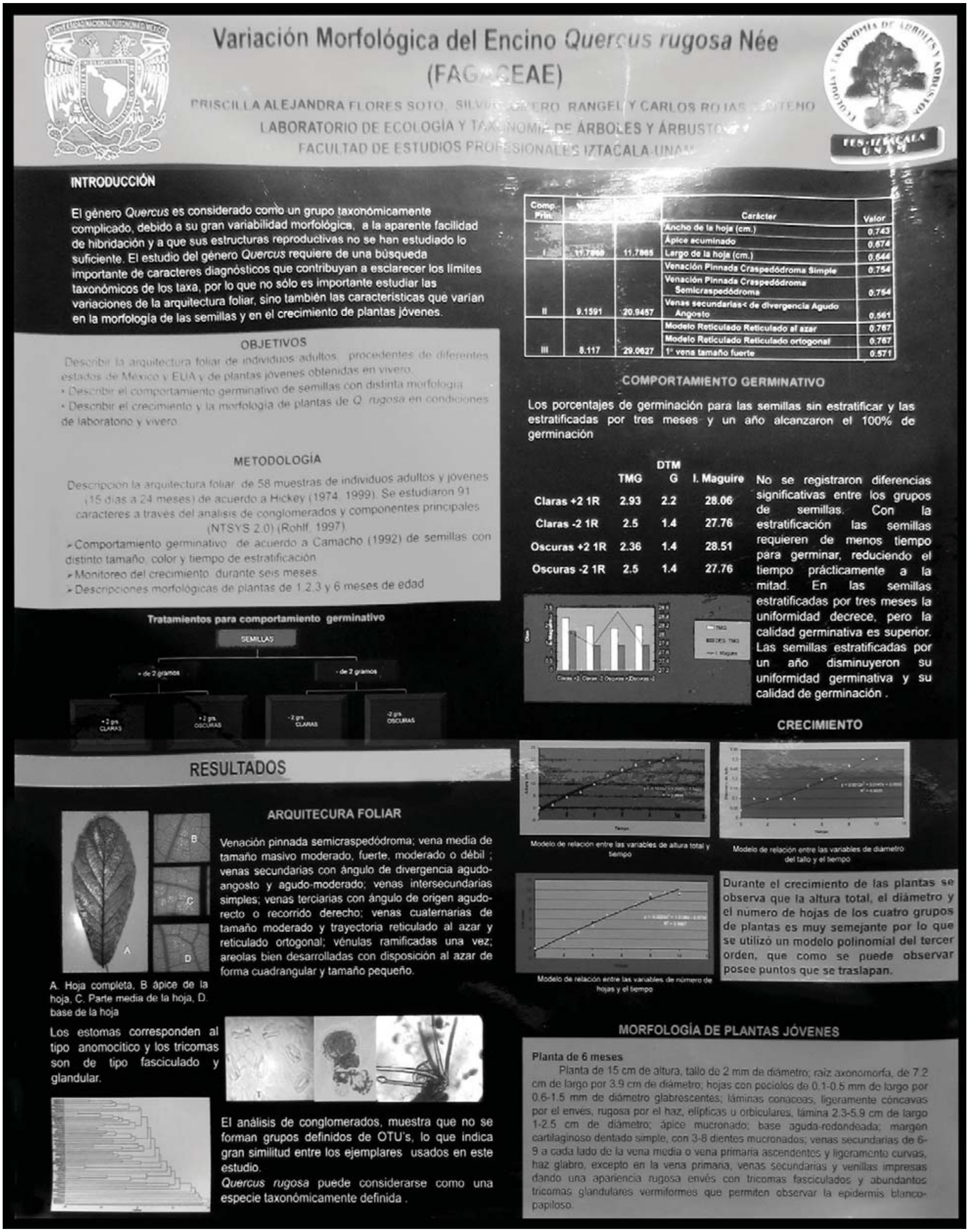
The diverse Mexican oak forests are exploited at a local level, but not on an industrial scale (Rzedowski, 1978). This low exploitation is mainly because of the difficulty in working the hard wood and lack of technological studies of potentially commercial species in the country.

Oak wood is primarily used for pulp (54%), scantling (30%), fuel (7%), and charcoal (6%) (de la Paz Pérez *et all.,,* 2000).

On a national level, oak wood occupies the second place in exploitation after pines, with the main uses for pulp, railway sleepers, panelling, posts, and fuel (Bárcenas 1985).

In comparison, in the USA and Europe, oak wood has been considered as one of the woods with the best characteristics for the construction of ships and outdoor structures, as well as barrels and quality furniture manufacture (Bárcenas, 1985).


Variación Morfológica del Encino Quercus rugosa Née
PRISCILLA ALEJANDRA FLORES SOTO, RANGEL Y CARLOS ROJAS
LABORATORIO DE ECOLOGÍA Y ÁRBOLES Y ÁRBUSTOS
FACULTAD DE ESTUDIOS IZTACALA
INTRODUCCIÓN
El género Quercus es considerado como un grupo taxonómicamente complicado, debido a su gran variabilidad morfológica, a la aparente facilidad de hibridación y a que sus estructuras reproductivas no se han estudiado lo suficiente. El estudio del género Quercus requiere de una búsqueda importante de caracteres diagnósticos que contribuyan a esclarecer los límites taxonómicos de los taxa, por lo que no sólo es importante estudiar las variaciones de la arquitectura foliar, sino también las características que varian en la morfología de las semillas y en el crecimiento de plantas jóvenes.
OBJETIVOS
Describir la arquitectura foliar de individuos adultos procedentes de diferentes estados de México y EUA y de plantas jóvenes obtenidas en vivero.
• Describir el comportamiento germinativo de semillas con distinta morfología
• Describir el crecimiento y la morfología de plantas de Q. rugosa en condiciones de laboratorio y vivero
METODOLOGÍA
Descripción la arquitectura foliar de 58 muestras de individuos adultos y jóvenes (15 días a 24 meses) de acuerdo a Hickey (1974, 1999). Se estudiaron 91 caracteres a través del análisis de conglomerados y componentes principales (NTSYS 2.0) (Rohlf, 1997).
➢Comportamiento germinativo de acuerdo a Camacho (1992) de semillas con distinto tamaño, color y tiempo de estratificación
➢Monitoreo del crecimiento durante seis meses.
➢Descripciones morfológicas de plantas de 1,2,3 y 6 meses de edad
Tratamientos para comportamiento germinativo
SEMILLAS
+ de 2 gramos
- de 2 gramos
+2 grs. CLARAS
+2 grs. OSCURAS
-2 grs. CLARAS
-2 grs. OSCURAS
Comp. Prin.
Carácter
Valor
I 11.7865 Ancho de la hoja (cm.) 0.743
Ápice acuminado 0.674
Largo de la hoja (cm.) 0.644
Venación Pinnada Craspedódroma Simple 0.754
Venación Pinnada Craspedódroma Semicraspedódroma 0.754
II 9.1591 20.9457 Venas secundarias< de divergencia Agudo Angosto 0.561
Modelo Reticulado Reticulado al azar 0.767
Modelo Reticulado Reticulado ortogonal 0.767
III 8.117 29.0627 1° vena tamaño fuerte 0.571
COMPORTAMIENTO GERMINATIVO
Los porcentajes de germinación para las semillas sin estratificar y las estratificadas por tres meses y un año alcanzaron el 100% de germinación
TMG | DTM G | I. Maguire
Claras +2 1R 2.93 2.2 28.06
Claras -2 1R 2.5 1.4 27.76
Oscuras +2 1R 2.36 1.4 28.51
Oscuras -2 1R 2.5 1.4 27.76
No se registraron diferencias significativas entre los grupos de semillas. Con la estratificación las semillas requieren de menos tiempo para germinar, reduciendo el tiempo prácticamente a la mitad. En las semillas estratificadas por tres meses la uniformidad decrece, pero la calidad germinativa es superior. Las semillas estratificadas por un año disminuyeron su uniformidad germinativa y su calidad de germinación.
CRECIMIENTO
Modelo de relación entre las variables de altura total y tiempo
Modelo de relación entre las variables de diámetro del tallo y el tiempo
Modelo de relación entre las variables de número de hojas y el tiempo
Durante el crecimiento de las plantas se observa que la altura total, el diámetro y el número de hojas de los cuatro grupos de plantas es muy semejante por lo que se utilizó un modelo polinomial del tercer orden, que como se puede observar posee puntos que se traslapan.
RESULTADOS
ARQUITECURA FOLIAR
Venación pinnada semicraspedódroma; vena media de tamaño masivo moderado, fuerte, moderado o débil; venas secundarias con ángulo de divergencia agudo-angosto y agudo-moderado; venas intersecundarias simples; venas terciarias con ángulo de origen agudo-recto o recorrido derecho; venas cuaternarias de tamaño moderado y trayectoria reticulado al azar y reticulado ortogonal; vénulas ramificadas una vez; areolas bien desarrolladas con disposición al azar de forma cuadrangular y tamaño pequeño.
A. Hoja completa, B ápice de la hoja, C. Parte media de la hoja, D. base de la hoja
Los estomas corresponden al tipo anomocítico y los tricomas son de tipo fasciculado y glandular.
El análisis de conglomerados, muestra que no se forman grupos definidos de OTU's, lo que indica gran similitud entre los ejemplares usados en este estudio.
Quercus rugosa puede considerarse como una especie taxonómicamente definida.
MORFOLOGÍA DE PLANTAS JÓVENES
Planta de 6 meses
Planta de 15 cm de altura, tallo de 2 mm de diámetro; raíz axonomorfa, de 7.2 cm de largo por 3.9 cm de diámetro; hojas con peciolos de 0.1-0.5 mm de largo por 0.6-1.5 mm de diámetro glabrescentes; láminas coriaceas, ligeramente cóncavas por el envés, rugosa por el haz, elípticas u orbiculares, lámina 2.3-5.9 cm de largo 1-2.5 cm de diámetro; ápice mucronado; base aguda-redondeada; margen cartilaginoso dentado simple, con 3-8 dientes mucronados; venas secundarias de 6-9 a cada lado de la vena media o vena primaria ascendentes y ligeramente curvas, haz glabro, excepto en la vena primaria, venas secundarias y venillas impresas dando una apariencia rugosa envés con tricomas fasciculados y abundantes tricomas glandulares vermiformes que permiten observar la epidermis blanco-papiloso.

Study of Morphological Variation in *Quercus rugosa* Née (*Fagaceae*)

Priscilla Alejandra Flores Soto, Silvia Romero Rangel y Ezequiel Carlos Rojas Zenteno
Laboratorio de Ecología y Taxonomía de Árboles y Arbustos, Facultad de Estudios Superiores Iztacala. UNAM, México.
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Study of the genus *Quercus* requires careful search for diagnostic characters that help to make clear the taxonomic limits of the taxa; the objectives in this work were to describe the foliar architecture of 58 adult and juvenile individuals of *Quercus rugosa* Née.

Fruits were disinfected and stored. The germination of scarified seed with different colors and weight was described. The amount of growth in the laboratory and in the nursery were recorded. Analysis of similarity of foliar architecture did not show different groups, which indicates that the specimens used in this study were very similar. Germination in *Quercus rugosa* in all cases was 100%. The calculated index showed that stratification improved seed germination in three months, but there was more uniformity in the seeds that were not stratified. The Maguire index was higher for the seeds stratified for three months than for the ones stratified for one year.

During development of the plants it was observed that the total height, the height of the first pair of leaves, diameter, and leaf number of the four groups was very similar. *Quercus rugosa* has a wide distribution in Mexico and occupies diverse habitats but it maintains itself as a morphologically uniform group.

Quercus rugosa photo©Guy Sternberg

A Conference Gallery

Several conference participants share their images for us here. We had so many wonderful photos that it was very difficult to select an assortment for this gallery. We hope the ones we included will give everyone who could not attend a feeling for this great event, and will bring back fond memories for those who were lucky enough to be there. You will find three sets of images representing the Pre-Conference Tour, the Conference itself, and the Post-Conference Tour.

Pre-Conference Tour

Identifying oaks by the abaxial surfaces of the leaves - Dan Keiser (USA), Allen Coombes (Mexico), and Bill Funk (Australia). photo©Guy Sternberg

Photo Stop in Guerrero. photo©Guy Sternberg

The acorn walk. photo©Ron Lance

The acorn crawl. photo©Guy Sternberg

Antoine le Hardÿ de Beaulieu getting a good look at *Quercus scytophylla*.
photo©Guy Sternberg

The historic city of Taxco, seen from our Hotel La Borda at dusk.

photo©Guy Sternberg

Participants from a dozen countries experience the vegetation of Ecoguardas Park near Mexico City. photo©Guy Sternberg

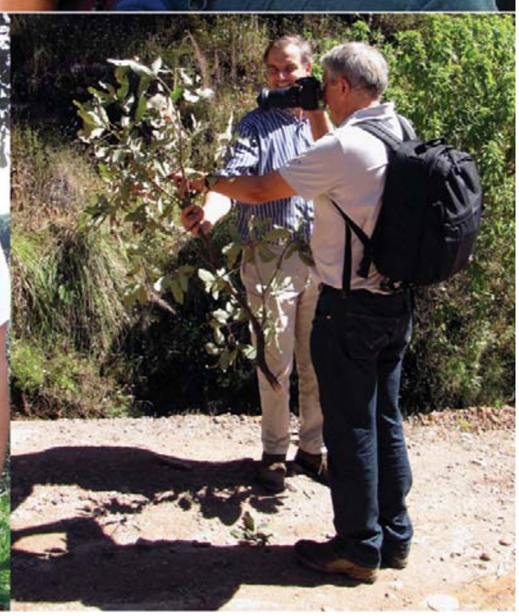
The typical "bubble bark" of a lichen-encrusted young *Quercus castanea*.

photo©Guy Sternberg

Kunso Kim with *Quercus conspersa* in Taxco. photo©Guy Sternberg

Renewing old friendships among the oaks

Maricela and Emily



Béatrice and Dan

Tonio and Michel

photo©Guy Sternberg, Gert Fortgens and Henry Eilers

Some of the world's top oak experts from France, Belgium, Mexico, and Spain try to identify oaks. photo©Béatrice Chassé

A local boy observing the International Oak Society.

photo©Guy Sternberg

The Conference

The magnificent Salon Barroco in Puebla, where we held our opening reception.
photo©Guy Sternberg

Maricela Rodríguez-Acosta begins the opening reception in the beautiful Salon Barroco in Puebla.
photo©Guy Sternberg

Opening ceremonies at the Benemérita University, Puebla Faculty Auditorium.

photo©Guy Sternberg

Outgoing IOS President Allen Coombes gavels the 2009 Conference to order. Maricela Rodríguez-Acosta, conference chairperson, is at right. Dr. Pedro Hugo Hernández Tejeda, Research and Postgraduate Studies Vice Chancellor for Benemérita University of Puebla, is at left. Ing. Manuel Herrera Sanchez, Puebla State Manager for the National Forestry Commission, Gulf-Center is at far left.

photo©Guy Sternberg

Dick and Riet van Hoey Smith, founding members, were unable to attend the conference. But they donated 30 pure silk scarves screened by Riet with oak leaves collected by Dick from Trompenburg Gardens and Arboretum, along with a key to the species. The scarves were given to participants at the business meeting, and were a big hit with the members who received them. Our hearty appreciation is extended to Dick and Riet for this generous (and educational!) donation, and for everything they have done over the years for the International Oak Society. photo©Gert Fortgens

Making things work behind the scenes: our skilled driver, Tomas Herrera Hernández and two of the students on Maricela's helpful team, Carolina and Lupita. photo©Guy Sternberg

Incoming Board of Directors

Charles Snyers d'Attenhoven, Belgium; Bill Hess, US; Béatrice Chassé, France; Dirk Benoit, Belgium; Allan Taylor, US; Allen Coombes, Mexico; Guy Sternberg, US; Rudy Light, US; Jim Hitz, US.

Outgoing Board of Directors 2006-2009

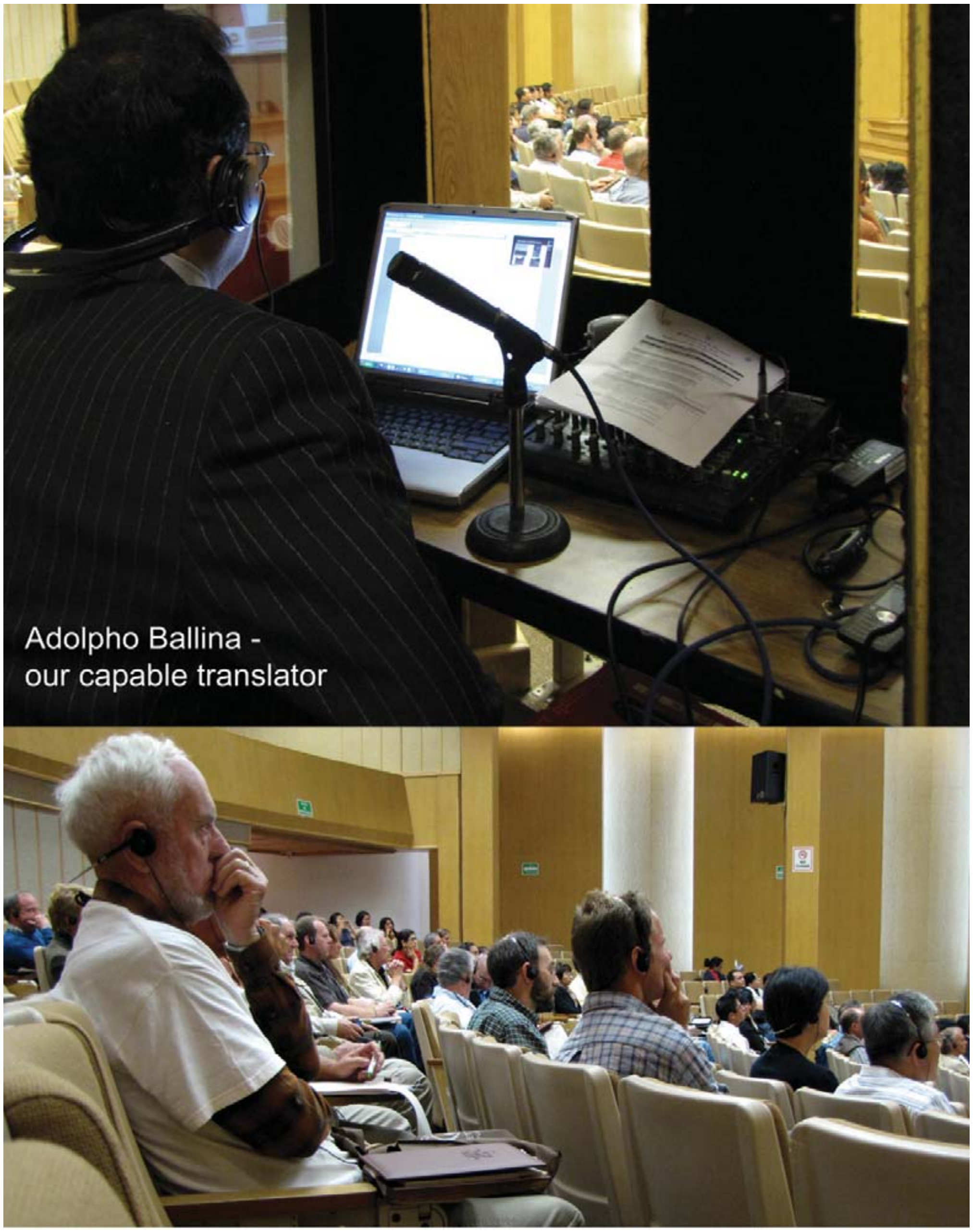
Ron Lance, US; Bill Hess, US; Allen Coombes, UK/Mexico; Guy Sternberg, US; Béatrice Chassé France; Dirk Benoit, Belgium; not present: Richard Jensen US; and Doug McCreary, US. photo©Michel Timacheff

May I have your acorn? photo©Guy Sternberg

Seed Exchange in a tent on the grounds of the Benemérita University of Puebla Botanic Garden. photo©Guy Sternberg

Carlos Alberto Guizado Hernández and Agustin Licea Muñoz who played a mix of traditional and contemporary music at the concert given during the opening ceremony of the Conference. photo©Guy Sternberg

2009 Conference attendees at Haras del Bosque for the final banquet.
photo©Guy Sternberg



Simultaneous translation using headphones was a very successful new experience for an IOS Conference. photo©Guy Sternberg

Night view of the cathedral near the hotels in Puebla. photo©Guy Sternberg

Several people contributed seeds even thouogh they could not attend - here Eike Jablonski collects acorns for the seed exchange from the ancient Feme Eiche in Germany, to be sent to Mexico with Jean-Claude Weber. Thanks Eike, and everyone else who contributed! photo©Carmen Jablonski

IOS Special Service Awards 2009
Michel Timacheff, Antoine le Hardÿ, Thierry Lamant, Matt Strong, Ron Lance.
photo©Guy Sternberg

Distracted by weeds while the rest of us found all the acorns: Béatrice Chassé, Dan Keiser, Gert Fortgens, Tim Boland, and Todd Lasseigne. photo©Guy Sternberg

The great volcano Popocatepetl rises over pines and oaks with its constant plume of smoke. photo©Guy Sternberg

Post-Conference Tour

Henry "Weeds" Eilers contemplates an Acorn (Bellota) machete at the street market in Cuetzalan. photo©Guy Sternberg

The rain pours down through leaves of *Quercus corrugata* in Cuetzalan.

photo©Henry Eilers

The IOS welcomes Dusan Placek and Ondrej Fous from the Czech Republic where we need to recruit oak enthusiasts as enthusiastic as they are (with Guy, three wild and crazy guys!). photo©Henry Eilers

Keiko Tokunaga (Japan), John Gammon (England), Thierry Lamant (France), and Gert Fortgens (Netherlands) take a break from the pouring rain at the beautiful Botanic Garden Fransisco Javier Clavijero in Xalapa.

photo©Guy Sternberg

The spectacular setting of Cuetzalan. photo©Guy Sternberg

Guy Sternberg in a large *Yucca periculosa* near Perote Volcano.

photo©Ron Lance

Quercus corrugata acorns (sack at forefront of photo) are collected in large quantities by a local resident, Amoparo Saldovar in Cuetzalan, for local crafts.

photo©Guy Sternberg

A field of *Quercus insignis* acorns. photo©B. Chassé

Henry "Weeds" Eilers with one of the largest acorns found.

Guy Sternberg with the harvest.
photo©Dan Keiser

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Triennial Conferences

2009 - Benemérita University, Puebla, Mexico
(Chair, Maricela Rodríguez-Acosta)

2006 - Texas A&M University, Texas, USA
(Chair, David Richardson)

2003 - King Alfred College, Hampshire, England
(Chair, Allen Coombes)

2000 - The North Carolina Arboretum, North Carolina, USA
(Chair, Ron Lance)

1997 - The Huntington Botanical Garden, California USA
(Chair, Amy Larson)

1994 - The Morton Arboretum, Illinois, USA
(Chair, Guy Sternberg)

Oak Open Days and their Organizers

2005 - England - Barry Denyer-Green

2004 - France - Thierry Lamant

2002 - Turkey - TEMA and led by Adil Güner, Habib Güler, Aydin Borazon and Nihat Gokyigit

2001 - Spain - Francisco Maria Vázquez

1999 - France - Thierry Lamant

1998 - Germany - Eike Jablonski

1995 - England - Allen Coombes and Dorothy Holley

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Material may be previously published or unpublished. The author's name, title, postal address, telephone and/or fax number, and e-mail (if available) should be provided and should include all information as intended for publication. Any contributions longer than 7500 words must be approved in advance by the editors.

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Tables and charts which are not submitted in camera-ready form (or in an electronic format approved in advance by the editors) may be rejected, or subjected to a minimum US$30 production fee. Patterns rather than colors should be used for purposes of clarity in monochromatic reproduction. All measurements should be expressed in metric units, or in metric followed (in parentheses) by English.

Nomenclature

Scientific names, with authority or with reference to the treatment in a specified standard taxonomic manual, must be included for each taxon discussed in scholarly papers. In names of nothotaxa, the multiplication sign is inserted with no space between the symbol and the initial letter of the name of the epithet. A space is used on both sides of the symbol in cases of formula names. If the mathematical symbol is not available, a lower-case Arial "x" may be used, with the same space suggestions. The "x" is neither italicized nor underlined. Inclusion of synonyms, formula names, and trade names in parentheses is encouraged where confusion may result from their omission. Cultivar names are capitalized and placed in single quotes and are not set in italics. Trade names are to be identified as such by the applicable standard symbols.

Review

The editorial committee and editors reserve the right to edit all contributions for grammar, correct English translation, current nomenclature, generally accepted taxonomic concepts, scientific accuracy, appropriateness, length, and clarity, but assume no responsibility to do so. If such review results in significant disputes of factual material, the author will be contacted if possible for approval before final publication, or the paper may be rejected. Every effort will be made to retain the original intent of the author. Graphics may be reconstructed or edited for clarity in publication, without altering their intent.

Submissions

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Text files or graphics smaller than 1 MB may be e-mailed to
guy@starhillforest.com

The Pre-Conference Tour Group
(Photo by Michel Timacheff, not pictured)

The Post-Conference Tour Group


Quercus rugosa

Quercus corrugata

Quercus insignis