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).

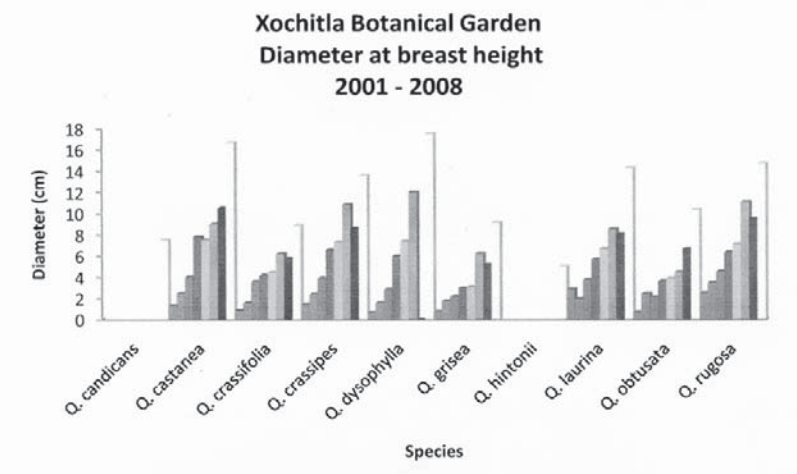
Forestry and phenology. A 2005 forestry and phenological study of the 11 *Quercus* species found that the period of growth occurs between May and September, while seed setting takes place between July and September. However, although it is often believed that only 30- to 40-year-old trees produce acorns, 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).

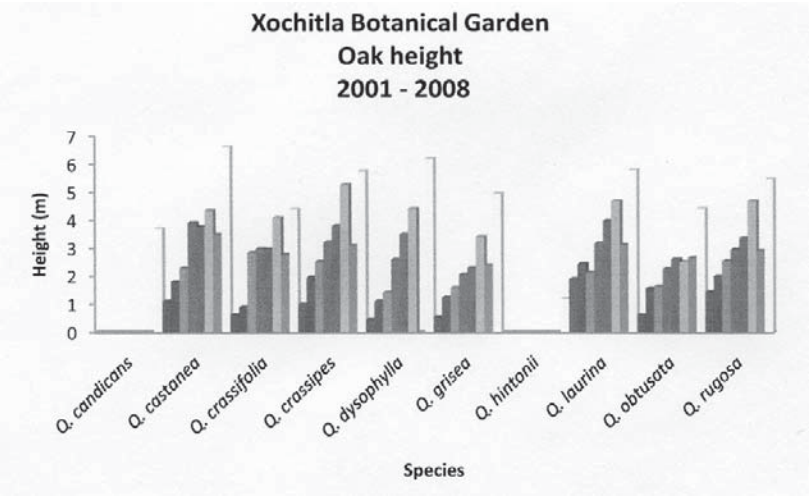
Each evaluation of the *arboretum* has several purposes: to estimate the survival of each species according to the year of planting; to take an annual census of the height and diameter of each tree in order to calculate development and growth parameters; to make an annual diagnosis of the health of the 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:

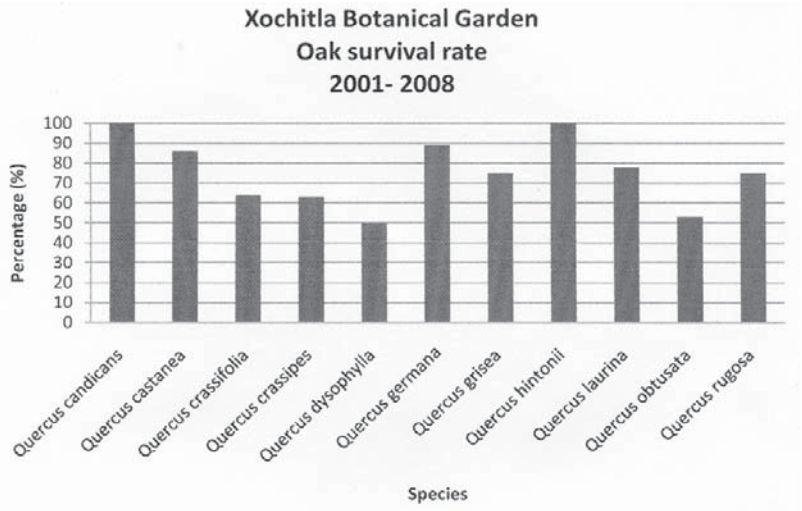
- Tree diameter and height (Graphs 1 and 2) are increasing gradually as a result of good maintenance conditions;
- The survival rate of the trees planted between 1999 and 2008 is between 50**% and** 100% (Graph 3). The major factors causing mortality during the early years of development were: a) low 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.

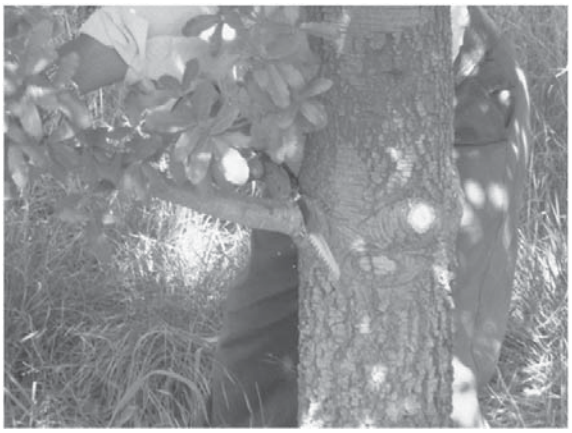


Fig. 3. Shaping a tree by pruning.

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