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Review Article

Uso de árboles nativos en áreas verdes urbanas: tendencias en el noreste de México

Use of native trees in urban green areas: trends in northeastern Mexico

Eduardo Alanís-Rodríguez[1], Arturo Mora-Olivo[2*], Javier Jiménez-Pérez[1], Gerardo Cuéllar-Rodríguez[1]

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[1]Facultad de Ciencias Forestales, Universidad Autónoma de Nuevo León. México
[2]Instituto de Ecología Aplicada, Universidad Autónoma de Tamaulipas. México

*Autor para correspondencia; correo-e: amorao@docentes.uat.edu.mx
*Corresponding author; e-mail: amorao@docentes.uat.edu.mx

Abstract

Urban trees mainly include species of introduced origin, although the use of native trees is increasingly common both in Mexico and in other regions of the world. The main objective of this study was to document the use of tree species in urban green areas in northeastern Mexico. Specifically, the following questions were raised: Are there changes in the use of species? What is the reason for these changes? What is the future trend in the use of species? In order to answer them, articles in web search engines were reviewed: ISI Web of Knowledge, EBSCO, SCOPUS, and Google Scholar. The results indicated that there were changes in the use of species. Three periods were identified: the first, from 1850 to 1980, when introduced species such as *Fraxinus americana* and *Ligustrum lucidium* were mainly used; from 1980 to 2000, when the use of native species such as *Quercus fusiformis* began; and from 2000 to the present, where the use of native species produced in local nurseries such as *Ebenopsis ebano* became established. The aspects that triggered these changes were the experiences with frosts, the generation of evidence by academics, the establishment of nurserymen in the region, and the creation and management of the Mexican Association of Arboriculture. The future trend in the use of species to reforest green urban areas is to preserve the native ones.

Key words: Trees, green areas, introduced species, native species, public parks, urban areas.

Resumen

El arbolado urbano incluye principalmente especies de origen introducido, aunque cada vez es más común el uso de árboles nativos tanto en México como en otras regiones del mundo. El objetivo principal de este estudio fue documentar el uso de taxones arbóreos en las áreas verdes urbanas del noreste de México. Específicamente, se plantearon las siguientes preguntas: ¿Existen cambios en el uso de especies? ¿A qué se deben esos cambios? ¿Cuál es la tendencia futura en el uso de especies? Para ello, se realizó una búsqueda en internet de artículos sobre el tema en los sitios: *ISI Web of Knowledge*, *EBSCO*, *SCOPUS* y *Google* académico. Los resultados indicaron que sí hubo cambios en los taxa utilizados. Se identificaron tres periodos: el primero de 1850 a 1980 en el cual se utilizaban, principalmente, especies introducidas como *Fraxinus americana* y *Ligustrum lucidium*; de 1980 a 2000, cuando se inicia el uso de taxones nativos como *Quercus fusiformis*; y del 2000 a la actualidad, en el que se consolida el empleo de especies nativas

producidas en viveros locales como *Ebenopsis ebano*. Los aspectos que detonaron esos cambios fueron las experiencias con las heladas, la generación de evidencia por parte de los académicos, la consolidación de los viveristas en la región y la creación y gestión de la Asociación Mexicana de Arboricultura. La tendencia futura apunta hacia la reforestación de las áreas verdes urbanas del noreste de México con especies nativas.

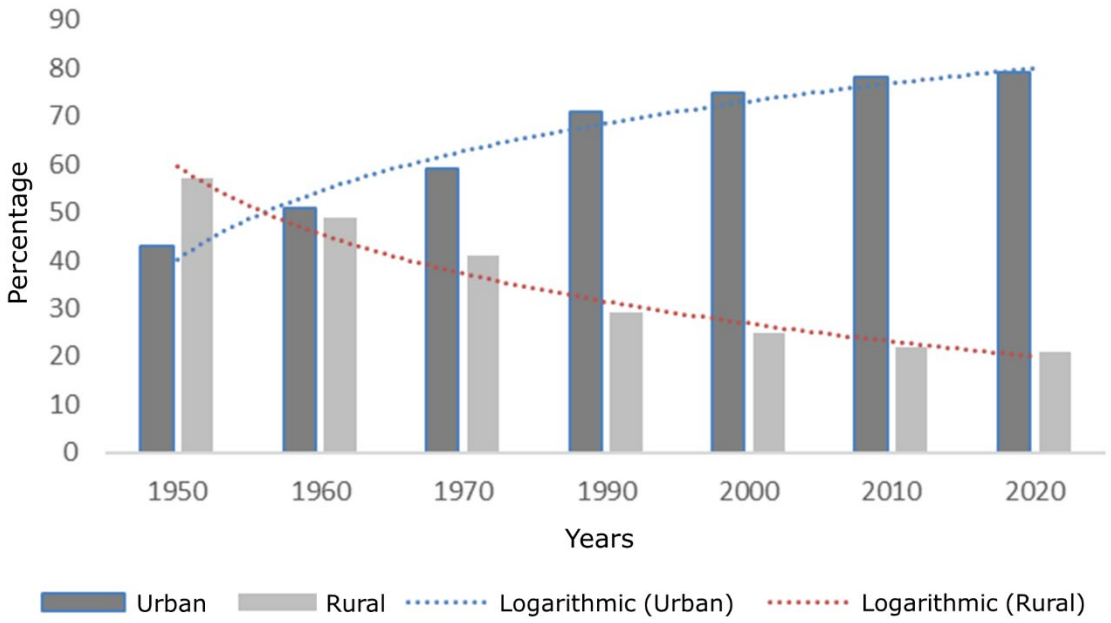
Palabras clave: Arbolado, áreas verdes, especies introducidas, especies nativas, parques públicos, zonas urbanas.

Introduction

Public parks are characterized by a plant species composition in which trees tend to dominate the landscape (Semeraro *et al*., 2021; Jiménez *et al*., 2022). Since the creation of the first urban areas, man has encouraged the use of trees for their own well-being, as they provide shade, food, or medicine, or are purely ornamental (Johnston, 2015; Camou-Guerrero *et al*., 2016). This principle of using tree species on private and public properties has been extended to urban areas all over the world (Sadler *et al*., 2010; Zhao *et al*., 2023).

The fact that 74.73 % of the population of Europe and more than 80 % of the population of North America live in urban areas confirms the importance of green spaces, especially considering that they are one of the main indicators of quality of life in a city (Hernández and Cruz, 2020). Soloaga *et al*. (2021) and the *Instituto Nacional de Estadística y Geografía* (National Institute of Statistics and Geography, Inegi, 2022) point out that the number of inhabitants of a locality determines whether it is rural or urban. A population is considered rural if it has less than 2 500 inhabitants, and urban if it exceeds 2 500.

Figure 1 shows how the percentage of Mexico's urban population has increased logarithmically (R^2=0.9634), while the percentage of the rural population is decreasing logarithmically (R^2=0.9634). In 1950, the percentage of rural population was higher (57 %); however, by 2020, it decreased to 21 %, and the urban sector increased to represent 79 % of the total.



Prepared by the authors with data from Inegi (2022).

Figure 1. Percentage of urban and rural population in Mexico from 1950 to 2020.

Decisions on the use and management of species for tree planting in urban areas are made by citizens, urban developers, or public officials (Andrade *et al.*, 2021). However, ecological studies of these wooded areas help to know the current state of these areas. For example, tree assessment allows understanding of various elements such as the number of trees per surface area, total or crown height, crown area, basal area, or timber volume (Alanís *et al.*, 2020; García-García *et al.*, 2022). All this information is important for understand how tree composition and structure changes over time and provides the basis for proposing better management strategies (Andrade *et al.*, 2021; Zhao *et al*., 2023).

In general, the floristic composition and the origin of the trees have been observed to change over time. A well-documented case is that of Mexico City's *Alameda Central*, which modified the use of species according to urban needs over a period of three centuries (Benavides, 2023). In northeastern Mexico, there have also been temporary changes in the use and origin of trees in the main

cities (Zamudio *et al*., 2001; Leal *et al*., 2018). Therefore, the objective of this study was to document trends in the use of species in the forestation of urban green areas in northeastern Mexico. Specifically, the following questions were asked: Are there changes in the use of species?, What are the reasons for these changes?, What is the future trend in the use of species?

Development and Discussion

A search for scientific articles and theses describing or evaluating trees in urban green areas in northeastern Mexico was carried out, using the following internet sites: ISI Web of Knowledge, EBSCO, SCOPUS, Google Scholar. The keywords used were: urban forestry, urban green areas, arboriculture, and urban trees.

There are records of qualitative research by Alanís and González (2003), Alanís *et al.* (2004), Alanís (2005), Zurita and Elizondo (2009), and Mora-Olivo and Martínez-Ávalos (2012), in which the species characteristic of the areas of interest are described, and some of the dates of their introduction are cited. In addition, Zamudio's quantitative research was recorded (2001), Alanís *et al.* (2014), Leal *et al*. (2018), Canizales *et al.* (2020), López (2020), and Alanís *et al*. (2022) considered in the inventory the taxa with the highest abundance and the Importance Value Index (*IVI*). Three contrasting stages were determined according to the information gathered: 1850 to 1980, 1980 to 2000, and 2000 to the present (Table 1).

Table 1. Main tree species planted in cities in northeastern Mexico.

Scientific name	Common name	Origin	Natural distribution	Planting period
Carya illinoinensis (Wangenh.) K. Koch	Walnut tree	Native	Southeast of the United States of America, northeast, center, and south of Mexico	2000-2020
Cordia boissieri A. DC.	*Anacahuita*	Native	South of Texas and northeast of Mexico	2000-2020
Ebenopsis ebano (Berland.) Barneby & J. W. Grimes	Texas ebony	Native	South of Texas, northeast of Mexico, *San Luis Potosí*, *Sinaloa*, *Durango*, *Jalisco, Zacatecas*, *Veracruz,* and *Yucatán Peninsula*	2000-2020
Ehretia anacua (Terán & Berland.) I. M. Johnst.	Knockaway	Native	South of Texas, northeast of Mexico, *Querétaro*, *San Luis Potosí*, *Jalisco*, *Michoacán*, *Guerrero*, and *Veracruz*	2000-2020
Fraxinus berlandieriana A. DC.	Mexican ash	Native	Southeast of the United States of America, northeast of Mexico, *Durango*, *San Luis Potosí*, *Michoacán*, *Estado de México* and *Veracruz*	1950-1960
Fraxinus uhdei (Wenz.) Lingelsh.	Shamel ash	Native	Mexico to Bolivia	1950-1960
Populus mexicana Wesm. ex DC.	Mexican poplar	Native	Endemic of Mexico : *Sonora*, *Sinaloa*, *Durango*, *Nuevo León*, *Tamaulipas*, *San Luis Potosí*, *Hidalgo*, *Veracruz*, *Puebla*, *Oaxaca* and *Chiapas*	2000-2020
Populus tremuloides Michx.	Trembling aspen	Native	Canada, United States of America, north and center of Mexico	1920-1940
Quercus fusiformis Small	Plateau oak	Native	United States of America (Oaklahoma and Texas), northeast of Mexico (*Coahuila*, *Nuevo León* and *Tamaulipas*)	1990-2000
Salix nigra Marshall	Black willow	Native	Canada, United States of America, north and center of Mexico	1920-1940
Araucaria columnaris (J. R. Forst.) Hook.	Araucaria	Introduced	Asia	1960-1970

Broussonetia papyrifera (L.) L'Hér. ex Vent.	Paper mulberry	Introduced	Asia	1980-1990
Casuarina equisetifolia L.	Horsetail she-oak	Introduced	Australia	1960-1970
Ficus benjamina L.	Ficus tree	Introduced	Asia	1980-1990
Ficus elastica Roxb. ex Hornem.	Panama rubber tree	Introduced	Asia	1950-1960
Fraxinus americana L.	American ash	Introduced	East of the United States of America	1950-1960
Koelreuteria bipinnata Franch.	Chinese flame tree	Introduced	Asia	1950-1960
Lagerstroemia indica L.	Crêpe myrtle	Introduced	Asia	1950-1960
Leucaena leucocephala (Lam.) de Wit	White leadtree	Introduced	Southeast of Mexico, Central America, and the Antilles	1980-1990
Ligustrum japonicum Thunb.	Japanese privet	Introduced	Asia	1920-1940
Pinus eldarica Medw.	Eldar pine	Introduced	Europe	1950-1960
Populus nigra L.	Black poplar	Introduced	Europe	1920-1940
Quercus macrocarpa Michx.	Bur oak	Introduced	Canada and east of the United States of America	1989-2000
Quercus rubra L.	Northern red oak	Introduced	Southeast of Canada and east of the United States of America	1990-2000
Quercus virginiana Mill.	Southern live oak	Introduced	Southeast of the United States of America	1990-2000
Triadica sebifera (L.) Small	Chinese tallowtree	Introduced	Asia	1970-1980
Syagrus romanzoffiana (Cham.) Glassman	Queen palm	Introduced	South America	1950-1960
Thuja occidentalis L.	Northern white cedar	Introduced	Southeast of Canada and northeast of the United States of America	1950-1960
Washingtonia filifera (Gloner ex Kerch., Burv., Pynaert, Rodigas & Hull) de Bary	Desert fan palm	Introduced	Southwest of the United States of America, Mexico (*Baja California*)	1950-1960
Washingtonia robusta H. Wendl.	Skyduster	Introduced	*Baja California* and *Sonora*	1950-1960

Stages of planting in urban areas of northeastern Mexico

1850-1980 period. The first record of species used in the urban green areas of the city of Monterrey was in 1850, with the establishment of the *Alameda* public park. Alanís *et al*. (2004) cite the planting of black willows (*Salix nigra* Marshall), American poplars (*Platanus* spp.), and American ash trees (*Fraxinus* spp.). Between 1920 and 1940, in the cities of northeastern Mexico, taxa acquired from nurseries in central Mexico and some local nurseries were used, where fast-growing introduced species such as American ash trees (*Fraxinus americana* L.), black poplars (*Populus nigra* L.), trembling aspens (*Populus tremuloides* Michx.), and privets (*Ligustrum lucidum* W. T. Aiton) were produced.

In 1960, introduced tree species mainly produced in nurseries in the central region of the country, still continued to be used; these included American ash trees (*Fraxinus americana*), rubber trees (*Ficus elastica* Roxb. ex Hornem.), Norfolk Island Pine (*Araucaria excelsa* (Lamb.) W. T. Aiton), horsetail she-oak trees (*Casuarina equisetifolia* L.), and French tamarisk (*Tamarix gallica* L.), all of which exhibit an accelerated development, as well as large crowns that form a broad shade cover. However, these taxa are very susceptible to low temperatures, which caused them to almost disappear from northeastern Mexico during the winter of 1967, due to frost (Alanís, 2005).

1980–2000 period. In the 1980s and 1990s, monospecific plantations with introduced trees were still common. During that period, monospecific ficus (*Ficus*

benjamina L.) plantations were made in the parks and sidewalks of the new housing developments in the cities of *Monterrey*, *Ciudad Victoria*, and *Linares* (Zamudio, 2001).

Alanís *et al*. (2004) document that the first efforts to carry out urban plantations with native species were made in the 1980s in *San Pedro Garza García* municipality (*Monterrey* Metropolitan Area). This municipality has the highest per capita income in Latin America and has an innovative management system (Gobierno de México, 2023). In that decade, academics and researchers from the *Universidad Autónoma de Nuevo León* and municipal officials responsible for urban green areas began planting native species.

In the 1990s, nursery gardeners in the citrus-growing region of *Nuevo León* sought advice from academics at regional universities and began to produce native species. This type of synergy between producers and universities has been successfully implemented in various parts of the world (Verheyen *et al*., 2023).

The species that produced the most was the southern live oak (*Quercus virginiana* Mill.), an evergreen taxon with a dense crown and a height of 15 to 20 m (Conafor, 2010; Romero *et al*., 2015), characteristics that helped its rapid acceptance, as one of the attributes sought by city dwellers is that the trees maintain their foliage and form dense canopies that generate shade (Alanís 2005, Lowry *et al*., 2012). The production of this species was carried out with seeds from Texas and northeastern Mexico. According to studies like those by Peña *et al.* (2012), *Q. virginiana* was considered to have varieties, of which the one corresponding to the northeastern part of the country was *Q. virginiana* var. *fusiformis* (Small) Sarg. However, more rigorous taxonomic research (Nixon, 1997; Pérez and Valencia, 2017) indicate that they are two different species: *Q. fusiformis* Small is native to northeastern Mexico, while *Q. virginiana* is distributed in the southeastern United States of America. The presence of both taxa was determined based on the identification of some *Quercus* specimens planted in the urban green areas of *Monterrey*, *Linares* and *Ciudad Victoria*.

2000–the present period. In the 2000s, the use of native species in cities was strongly promoted and established due to several factors, including:

- The experience of citizens, officials, and natural resource managers with the frosts that occurred in 1997 and 2011 in northeastern Mexico, which caused the death of a large number of introduced tropical tree species (Alanís, 2011).
- Generation of evidence by academics and researchers from regional universities indicating the advantages of using native species.
- Establishment of nurseries in the region for the production of native and naturalized species adapted to the region.
- Creation and permanent management of the Mexican Association of Arboriculture for the promotion of the use of native taxa.

During this period, a synergy was generated between nursery gardeners, managers of green areas, academia, and civil servants to work and promote the use of native species. For this purpose, we implemented consultancies, courses, workshops, and lectures, as well as the publication of scientific articles and books (Alanís and González, 2003; Alanís *et al.*, 2004; Zurita, 2009; Mora-Olivo and Martínez-Ávalos, 2012; Alanís *et al.*, 2014; Leal *et al*., 2018; Canizales *et al*. 2020; Cavazos and Cavazos, 2021).

Current composition of urban forests

According to quantitative research by Alanís *et al.* (2014), Leal *et al.* (2018), López (2020), Canizales *et al.* (2020), and Alanís-Rodríguez *et al*. (2022) the native species with the largest number of individuals are *Carya illinoinensis* (Wangenh.) K. Koch, *Cordia boissieri* A. DC., *Ebenopsis ebano* (Berland.) Barneby & J. W. Grimes,

Ehretia anacua (Terán & Berland.) I. M. Johnst., *Fraxinus uhdei* (Wenz.) Lingelsh., *Populus mexicana* Wesm. ex DC., *Populus tremuloides*, and *Quercus fusiformis*. All these taxa share an arboreal growth form, with broad and dense canopies that provide shade. In addition to these tree species, there are others which are also found in urban forests but are less abundant, *e. g. Acacia farnesiana* (L.) Willd., *Prosopis laevigata* (Humb. & Bonpl. ex Willd.) M. C. Johnst., *Diospyros texana* Scheele, and *Parkinsonia aculeata* L. (Mora-Olivo and Martínez-Ávalos, 2012).

Many introduced species that were planted have disappeared due to the low temperatures in northeastern Mexico. The most significant frosts in the last 100 years occurred in 1925, 1949, 1967, 1983, 1997, and 2011 (Guerrero, 2014). Zamudio (2001) and Alanís (2011) point to the rubber leaf tree (*Ficus elastica*), Norfolk Island Pine (*Araucaria excelsa*), horsetail she-oaks (*Casuarina equisetifolia*), French tamarisks (*Tamarix gallica*), ficus trees (*Ficus benjamina*), and Chinese tallowtrees (*Triadica sebiferum* (L.) Small) as some of the species that were planted on a large scale and perished with the frost.

Based on the quantitative research by Alanís *et al.* (2014), Leal *et al.* (2018), Canizales *et al.* (2020), López (2020), and Alanís *et al*. (2022) conducted in urban green areas in northeastern Mexico, the introduced species with the highest number of specimens and the highest Importance Value Index were identified as American ash (*Fraxinus americana*), Japanese privet (*Ligustrum japonicum* Thunb.), northern white cedar (*Thuja occidentalis* L.), Chinese flame tree (*Koelreuteria paniculata* Laxm.), and the *Syagrus romanzoffiana* (Cham.) Glassman and *Washingtonia filifera* (Gloner ex Kerch., Burv., Pynaert, Rodigas & Hull) de Bary palms, which were planted before 2000 and are frost-tolerant.

Conclusions

In relation to the first question, it is concluded that changes in the use of the species were determined by their origin. Three periods were identified: 1) 1850 to 1980, when introduced species from nurseries in central Mexico were mainly used; 2) 1980 to 2000, when the use of native species produced in local nurseries was initiated; and 3) 2000 to the present, when the use of native taxa produced in local nurseries has become established.

As for the second question, we propose that the changes are due to various causes. The triggering situations were the experiences of citizens, civil servants, and natural resource managers with frost, the evidence generated by academics and researchers from regional universities, which indicates the advantages of using native species; the establishment of nurseries in the region to produce both native and naturalized taxa adapted to the region, and the creation and permanent management of the Mexican Association of Arboriculture in the promotion of the use of native species.

With regard to the third question and based on the synergy observed between nursery gardeners, managers of green areas, academics, and civil servants, the future trend in the reforestation of urban green areas will be to maintain the use of native taxa, as well as increase the number of species that are produced, with greater equity of individuals of each species, that is to say, diversity will be increased both in terms of floristic richness and equity of individuals per species. In order to achieve this, it is important to carry out precise forest inventories and to estimate in detail the phytodiversity and the quantitative elements of the tree structure.

In addition to the above, it is essential to consider that not all native tree species are easily adapted to cultivation in public parks. Such is the case of those that naturally develop in riparian or aquatic environments, *e. g.* ash trees (*Fraxinus berlandieriana* A. DC. and *F. uhdei*), willows (*Salix nigra*), and the Montezuma

cypress (*Taxodium mucronatum* Ten.). We therefore recommend planting these on the shores of artificial lakes or where there is a constant source of moisture.

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Conflict of interest

The authors declare no conflict of interest.

Contribution by author

Eduardo Alanís-Rodríguez: development of the idea, database and writing of the manuscript; Arturo Mora-Olivo: interpretation of results and writing of the Conclusions; Javier Jiménez-Pérez: data analysis and writing of Introduction; Gerardo Cuéllar Rodríguez: literature review and writing of the Methodology. All authors reviewed the manuscript.

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