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Article

Estructura, composición y diversidad del arbolado urbano de Linares, Nuevo León

Structure, composition and diversity of the urban forest of *Linares, Nuevo León*

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Resumen

Los bosques urbanos y áreas verdes de las ciudades proveen beneficios directos a la población, como mejorar la temperatura y la calidad del aire, protegen el suelo y permiten la permeabilidad de agua al subsuelo. El objetivo del trabajo fue determinar la estructura, composición y diversidad del arbolado urbano de Linares, Nuevo León. Se recabó información dasométrica de áreas verdes urbanas y parques públicos; se trabajó con seis camellones, 14 parques y 25 plazas con una superficie de 273 904 m^2. Se registró el diámetro normal ($d_{1.30}$), la altura total (h) y el diámetro de copa (d_{copa}). Se calculó la densidad de especies vegetales por área verde urbana y su número total. La diversidad fue evaluada mediante los índices de *Shannon-Weiner* y de *Margalef*. El total de individuos fue de 2 066, pertenecientes a 41 especies, 34 géneros y 25 familias. La más representativa fue Fabaceae con seis taxones; *Fraxinus americana* (fresno) es sobresaliente desde el punto de vista ecológico, con 25.67 N ha^{-1}, que representa 34.03 % de la abundancia total, 1 225.38 m^2 ha^{-1} que equivale a 46.93 % de dominancia y 30.91 % de IVI; seguida de *Quercus virginiana* con 22.46 % y *Washingtonia robusta* con 11.56 %. El índice de Shannon-Weiner registró un valor de H' = 1.99 y H'_{max} = 3.17, y el índice de Margalef D_{Mg} = 5.24. Se concluye que el arbolado urbano estudiado está compuesto, principalmente, por especies introducidas, de las cuales la más importante es el fresno.

Palabras clave: Abundancia, áreas verdes, bosque urbano, dominancia, índice de Margalef, índice de Shannon.

Abstract

The urban forests and green areas of the cities provide direct benefits to the population such as improving the temperature and air quality, protect the soil and allow the permeability of water to the subsoil. The aim of this study was to determine the structure, composition and diversity of the urban trees of *Linares, Nuevo León*. Dasometric information was collected from urban green areas and public parks, counting 6 ridges, 14 parks and 25 public spaces with a total area of 273 904 m^2. The variables of diameter ($d_{1.30}$), total height (h) and diameter of the crown (d_{crown}) were recorded. The density of plant species by urban green area and the total number of species was calculated. Diversity was assessed using the Shannon-Weiner and Margalef indices. The total number of trees registered was 2 066 belonging to 41 species, 34 genera and 25 families. The most representative was Fabaceae with six species; *Fraxinus americana* (ash) is outstanding from the ecological point of view, with 25.67 N ha^{-1}, which represents 34.03 % of total abundance and 1 225.38 m^2 ha^{-1} which is equivalent to 46.93 % of dominance and 30.91 % of IVI, followed by *Quercus virginiana* with 22.46 % and *Washingtonia robusta* with 11.56 %. The Shannon-Weiner Index recorded H'= 1.99 and H'_{max} = 3.17, and the Margalef Index D_{Mg} = 5.24. It is concluded that the urban trees described here are mainly composed of introduced species, the most important of which is ash.

Key words: Abundance, green areas, urban forest, dominance, Margalef index, Shannon index.

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Introduction

Cities are home to a growing proportion of the world's population, and in the face of urban sprawl, green areas play a key role in maintaining social, economic and ecological well-being (McDonnell and Hahs, 2009; Acharya, 2011; Ramalho and Hobbs, 2012). Urban parks are green areas managed mainly for the purpose of coexistence and recreation, and unlike forests or protected parks, they are the most accessible green spaces for the population residing in urbanized areas (Oleyar *et al*., 2008; Nagendra and Gopal, 2011; Niemelä *et al.*, 2011). Urban parks also provide multiple environmental services: mitigate air pollution, reduce noise, provide scenic beauty, recreation, opportunities for contact with nature (Dobbs *et al*., 2011; Escobedo *et al*., 2011; Zhang and Jim, 2014); and they favor the conservation of biological diversity by giving habitat and food to the local fauna (Chace and Walsh, 2006; Cabó-Ramírez and Zuria, 2011).

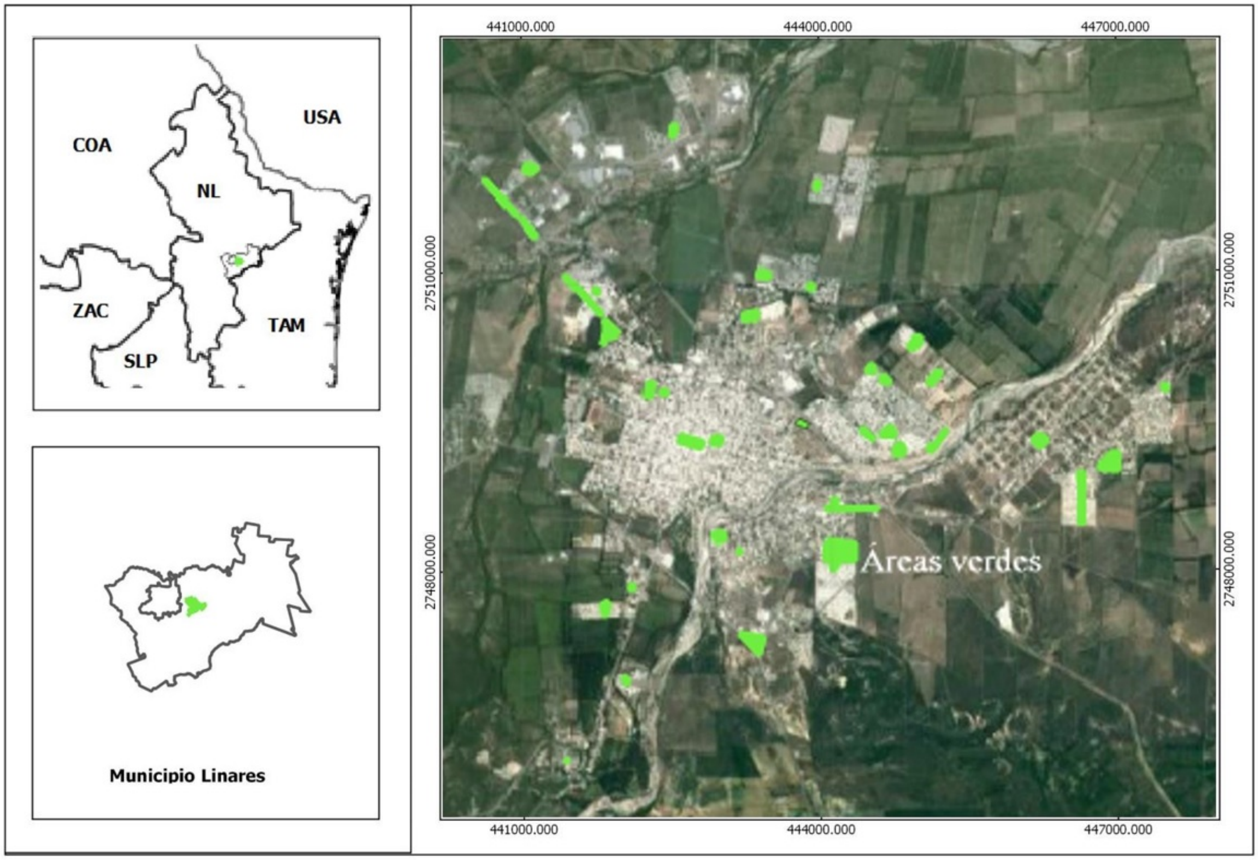
There is considerable information describing the composition and diversity of trees in urban parks in various parts of the world, and in the United States, Europe and Asia, where they have developed most (Lososová et al., 2011; Nagendra and Gopal, 2011; Jim and Zhang, 2013; Pesola *et al*., 2017; Riley *et al*., 2017). In Mexico, there is not much information about the green areas within the urban areas of several cities. The best assessed areas are large metropolis such as Mexico City, where general studies have been conducted covering the entire urban area (Benavides, 1992; Checa-Artasu, 2016) or on a particular area such as *Chapultepec* Forest (Benavides and Young, 2012).

In the northeastern part of Mexico, there are few records on the subject of green areas and urban forests. Alanís (2005) and Jiménez *et al.* (2013) evaluated the green areas of the *Monterrey* municipality, *Nuevo León*, through geographic information systems and *in situ* forest inventories. In *Tamaulipas*, Mora and Martínez (2012) elaborated a work on the wild plants of an urban forest located in *Ciudad Victoria*. In the case of the municipality of *Linares, Nuevo León*, information is scarce and limited to studies carried out on the main square of the city on the trees on the sidewalks (Zamudio, 2001) and on a student campus (Alanís *et al*., 2014). Based on the above, the objective of this study was to determine the structure, composition and diversity of urban trees in the different squares, parks and ridges of the urban area of *Linares, Nuevo León*.

Materials and Methods

Study area

The *Linares* municipality (Figure 1) is located southeast of the state of *Nuevo León*. Geographically it limits towards the north with the *Hualahuises* and *Montemorelos* municipalities; both to the south and to the east with the state of *Tamaulipas* and to the west with *Galeana* and *Iturbide* municipalities. Its geographic coordinates correspond to 24°51' N and 99°24' W (Municipios Mx, 2018).



Upper left image = NE of Mexico and SE United States of America; Lower left image = *Linares* municipality, *Nuevo León*; Right image = *Linares* urban area with its green areas; COA = *Coahuila*; NL = *Nuevo León*; ZAC = *Zacatecas*; SLP = *San Luis Potosí*; TAM = *Tamaulipas*.

Figure 1. Location of the study area.

Floristic inventory

A census was made of all the plant species present in public areas such as plazas, parks and ridges of the city of *Linares*. Thus, it was considered that the squares and parks are clearly delimited public spaces, dominated by vegetation and intended as public green areas for the realization of recreational or outdoor sports activities. This information was collected during the months of March and April 2016.

The dendrometric variables of normal diameter ($d_{1.30\ m}$) were measured with a Haglöf Mantax Blue 1270 mm caliper; total height (h), with a Suunto PM-5 hypsometer; and the diameter of the crown (d_{crown}), with a 100 m metric cross fiber glass Truper™, tape according to the four cardinal points north-south and east-west. The coordinates of each square, park and ridge were recorded with an eTrex 20x Garmin® mountain crossing GPS.

Data analysis

For each species, their abundance was determined, according to the number of trees, their coverage, depending on the crown area, and their frequency based on their presence in the sampling sites. The relativized variables were used to obtain a weighted value at the taxon level called the Importance Value Index (IVI), which acquires percentage values on a scale of 0 to 100 (Mostacedo and Fredericksen, 2000).

For the estimation of relative abundance the following equation was used:

$$A_{i={}^{N_i}/_{S}} \qquad AR_{\underset{i=1\ldots n}{i=\left({}^{A_i}/_{\sum A_i}\right)*100}} \qquad (1)$$

Where:

AR_i = Relative abundance of the *i* species in regard to total abundance

A_i = Absolute abundance of the *i* species (N ha^{-1})

Dominance was calculated through the equation:

$$D_{i={}^{Ab_i}/_{S(ha)}} \qquad DR_{\underset{i=1\ldots n}{i=\left({}^{D_i}/_{\sum D_i}\right)*100}} \qquad (2)$$

Where:

DR_i = Relative dominance of the *i* species in regard to total dominance

D = Absolute dominance of the *i* species (m^2 ha^{-1})

The absolute and relative frequencies were obtained with the equations:

$$F_{i=} {}^{P_i}/_{NS} \qquad FR_{i=} \left({}^{F_i}/_{\sum_{i=1...n} F_i}\right)*100 \qquad (3)$$

Where:

F_i = Absolute frequency (percentage of presence in the sampling sites)

f_i = Number of sites in which de *i* species is present

N = Number of sampling sites

FR_i = Relative frequency of the *i* species in regard to total frequency

The Importance Value Index (IVI) is defined through the equation:

$$IVI = \frac{AR_i \ + DR_i \ + FR_i}{3}$$

To estimate the alpha diversity, we used the Margalef index (D_{Mg}) and the Shannon-Weiner index (H') [18], using the following equations:

$$D_{Mg=} \frac{(S-1)}{In(N)} \qquad (5)$$

$$H' = -\sum_{i=1}^{S} pi * In(p_i) \qquad pi = {}^{n_i}/_N \quad (6)$$

Where:

S = Number of present species

N = Total number of individuals

n_i = Number of individuals of the *i* species

By means of a correlation analysis, the relationship between the parameters of wealth and diversity and the distance of ages from urban parks was explored.

Results

There were 41 species belonging to 34 genera and 25 families of vascular plants (Table 1). The most representative family was Fabaceae with six species, Fagaceae with four species, later Moraceae and Arecaceae with three each, and finally, Bignoniaceae, Oleaceae, Pinaceae and Rutaceae with two. Of the 41 species recorded in the study, 14 were native and 27 exotic (Table 2).

Table 1. Distribution of species and number of individuals per assessed area.

	Areas	**Species**	**Individuals**
Squares	21	37	1 071
Parks	14	21	835
Ridges	6	9	160
Total	41	41	2 066

Table 2. Scientific and common name, family and origin of the tree species recorded in the study area.

Scientific name	Common name	Family	Origin
Azadirachta indica A.Juss.	*Neem*	Meliaceae	Exotic
Bauhinia variegata L.	*Pata de vaca*	Fabaceae	Exotic
Caesalpinia mexicana A.Gray	*Árbol del potro*	Caesalpinaceae	Native
Carya illinoinensis (Wangenh.) K.Koch	*Nogal*	Yuglandaceae	Native
Celtis laevigata Willd.	*Palo blanco*	Fabaceae	Native
Citrus sinensis (L.) Osbeck	*Naranjo*	Rutaceae	Exotic
Cordia boissieri A.DC.	*Anacahuita*	Boraginaceae	Native
Delonix regia (Bojer) Raf.	*Flamboyán*	Fabaceae	Exotic
Diospyros texana Scheele	*Chapote prieto*	Ebenaceae	Native
Ebenopsis ebano (Berland.) Barneby & J.W.Grimes.	*Ébano*	Fabaceae	Native
Eucalyptus globulus Labill*.*	*Eucalipto*	Myrtaceae	Exotic
Ficus benjamina L.	*Ficus*	Moraceae	Exotic
Ficus microcarpa L.f.	*Laurel de la India*	Moraceae	Exotic
Fraxinus americana L*.*	*Fresno*	Oleaceae	Exotic
Helietta parvifolia (A. Gray ex Hemsl.) Benth.	*Barreta*	Rutaceae	Native
Jacaranda mimosifolia D.Don	*Jacaranda*	Bignoniaceae	Exotic
Leucaena leucocephala (Lam.) de Wit	*Leucaena*	Fabaceae	Exotic
Ligustrum japonicum Thunb.	*Trueno*	Oleaceae	Exotic
Melia azedarach L.	*Canelón*	Meliaceae	Exotic
Phoenix dactylifera L.	*Palma datilera*	Arecaceae	Exotic
Pinus halepensis Mill.	*Pino halapensis*	Pinaceae	Exotic
Pinus pseudostrobus Lindl.	*Pino real*	Pinaceae	Native
Platanus rzedowskii Nixon & J.M.Poole	*Sicomoro*	Moraceae	Native
Prosopis laevigata (Humb. & Bonpl. ex Willd.) M.C. Johnst.	*Mezquite*	Fabaceae	Native
Prunus persica (L.) Batsch	*Durazno*	Rosaceae	Exotic
Punica granatum L.	*Granado*	Lythraceae	Exotic
Quercus macrocarpa Michx.	*Encino macrocarpa*	Fagaceae	Exotic
Quercus rubra L.	*Encino Rojo*	Fagaceae	Exotic
Quercus texana Buckley	*Encino Cartamus*	Fagaceae	Exotic

Quercus virginiana Mill.	*Encino siempre verde*	Fagaceae	Native
Salix humboldtiana Willd.	*Sauce*	Salicaceae	Exotic
Sapindus saponaria L.	*Jaboncillo*	Sapindaceae	Native
Sapium sebiferum (L.) Roxb.	*Chainis*	Euphorbiaceae	Exotic
Schinus molle L.	*Pirul*	Anacardiaceae	Exotic
Syagrus romanzoffiana (Cham.) Glassman	*Palma coco plumoso*	Arecaceae	Exotic
Tabebuia rosea (Bertol.) DC.	*Palo de rosa*	Bignoniaceae	Exotic
Taxodium mucronatum Ten.	*Sabino*	Taxodiaceae	Native
Thuja occidentalis L.	*Tuya*	Cupressaceae	Exotic
Vitex agnus-castus L.	*Árbol casto*	Lamiaceae	Exotic
Washingtonia robusta var. *gracilis* (Parish) Parish ex Becc.	*Palma Washingtonia*	Arecaceae	Exotic
Yucca filifera Chabaud	*Palma pita*	Asparagaceae	Native

A total abundance of 75.43 N ha^{-1} was recorded. The most outstanding species was *Fraxinus americana* L. with 25.67 N ha^{-1}, which represents 34.03 % of the total. *Quercus virginiana* Mill. with 28.61 % and *Washingtonia robusta* var. *gracilis* (Parish) Parish ex Becc. with 15.15 % follow; the remaining species together sum 22.21 %.

The crown coverage of the urban green areas (parks, squares and ridges) was 2 611.31 m^2 ha^{-1}. *Fraxinus americana* registered greater dominance with 1 225.38 m^2 ha^{-1}, followed by *Quercus virginiana* with 552.04 m^2 ha^{-1} and *Carya illinoinensis* (Wangenh.) K.Koch with 255.63 m^2 ha^{-1}; the remaining species represented 22.14 %.

Quercus virginiana stands out as the main species in urban green areas in *Linares*, as it was recognized 33 of the 41 green areas analyzed (17.65 %). *Washingtonia robusta* var. *gracilis* was in 25 of them, which is equivalent to 13.37 %, followed by *Fraxinus americana* in 22 (11.76 %).

The highest calculated value for the Importance Value Index was for *Fraxinus americana* with 30.91 %, followed by *Quercus virginiana* with 22.46 % and for *Washingtonia robusta* with 11.56 %, which together add up to 64.93 % (Table 3).

In contrast, *Citrus sinensis* (L.) Osbeck*, Punica granatum* L.*, Prunus persica* (L.) Batsch and *Tabebuia rosea* (Bertol.) DC.recorded 0.20 % each, which is the lowest value.

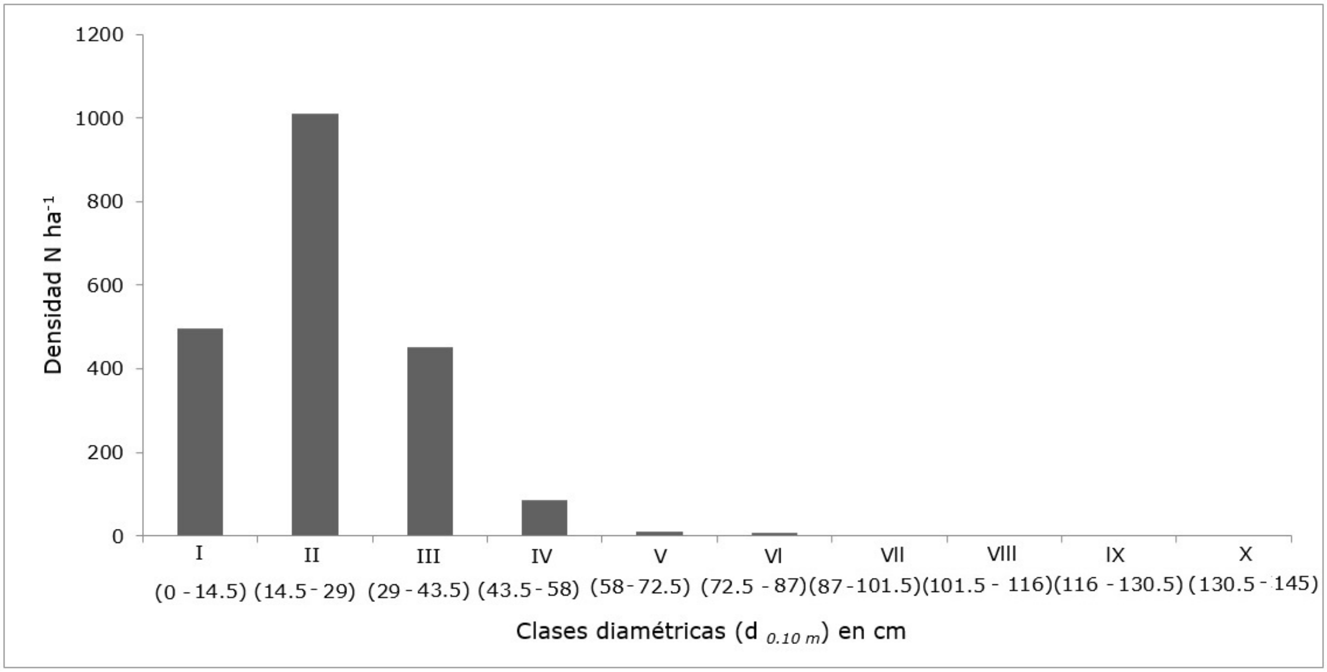
Table 3. Abundance (N ha^{-1}), dominance (m^2 ha^{-1}), frequency, Importance value Index of the species registered in urban green areas in *Linares*, N L.

Scientific name*	Abundance		Dominance		Frequency		Importance values	
	N ha^{-1}	**%**	m^2 ha^{-1}	**%**	**N/Site**	**%**	**IVI**	**IVI rel**
Fraxinus americana L.	25.67	34.03	1 225.38	46.93	22.00	11.76	92.72	30.91
Quercus virginiana Mill.	21.58	28.61	552.04	21.14	33.00	17.65	67.39	22.46
Washingtonia robusta var. *gracilis* (Parish) Parish ex Becc.	11.43	15.15	161.23	6.17	25.00	13.37	34.69	11.56
Carya illionensis (Wangenh.) K.Koch	2.15	2.86	255.63	9.79	10.00	5.35	17.99	6.00
Ligustrum japonicum Thunb.	3.50	4.65	75.96	2.91	5.00	2.67	10.23	3.41
Quercus rubra L.	1.50	1.98	32.97	1.26	8.00	4.28	7.53	2.51
Cordia boissieri A.DC.	0.51	0.68	12.64	0.48	8.00	4.28	5.44	1.81
Syagrus romanzoffiana (Cham.) Glassman	0.69	0.92	10.41	0.40	6.00	3.21	4.53	1.51
Quercus macrocarpa Michx.	0.47	0.63	11.32	0.43	6.00	3.21	4.27	1.42
Thuja occidentalis L.	1.02	1.36	21.77	0.83	3.00	1.60	3.79	1.26
Ebenopsis ebano (Berland.) Barneby & J.W.Grimes.	0.22	0.29	13.98	0.54	5.00	2.67	3.50	1.17
Azadirachta indica A.Juss.	0.47	0.63	13.11	0.50	4.00	2.14	3.27	1.09
Phoenix dactylifera L.	0.91	1.21	38.38	1.47	1.00	0.53	3.21	1.07
Pinus pseudostrobus Lindl.	0.80	1.06	23.45	0.90	2.00	1.07	3.03	1.01
Jacaranda mimosifolia D.Don.	0.44	0.58	21.13	0.81	3.00	1.60	2.99	1.00
Melia azedarach L.	0.26	0.34	10.99	0.42	4.00	2.14	2.90	0.97
Taxodium mucronatum Ten.	0.18	0.24	13.44	0.51	4.00	2.14	2.90	0.97
Leucaena leucocephala (Lam.) de Wit	0.18	0.24	9.53	0.36	4.00	2.14	2.75	0.92
Sapium sebiferum (L.) Roxb.	0.69	0.92	18.11	0.69	2.00	1.07	2.68	0.89
Bauhinia variegata L.	0.40	0.53	13.60	0.52	3.00	1.60	2.66	0.89
Ficus benjamina L.	0.29	0.39	12.64	0.48	3.00	1.60	2.48	0.83
Salix humboldtiana Willd.	0.15	0.19	2.15	0.08	3.00	1.60	1.88	0.63
Prosopis laevigata (Humb. & Bonpl. ex Willd.) M.C. Johnst.	0.11	0.15	9.84	0.38	2.00	1.07	1.59	0.53
Quercus texana Buckley	0.33	0.44	13.19	0.51	1.00	0.53	1.48	0.49
Yucca filifera Chabaud	0.15	0.19	4.41	0.17	2.00	1.07	1.43	0.48
Celtis laevigata Willd.	0.11	0.15	3.09	0.12	2.00	1.07	1.33	0.44

Delonix regia (Bojer) Raf.	0.11	0.15	2.13	0.08	2.00	1.07	1.30	0.43
Schinus molle L.	0.29	0.39	8.92	0.34	1.00	0.53	1.26	0.42
Diospyros texana Scheele	0.22	0.29	2.62	0.10	1.00	0.53	0.93	0.31
Platanus rzedowskii Nixon & J.M.Poole	0.11	0.15	3.06	0.12	1.00	0.53	0.80	0.27
Eucalyptus globulus Labill.	0.04	0.05	5.00	0.19	1.00	0.53	0.77	0.26
Helietta parvifolia (A. Gray ex Hemsl.) Benth.	0.11	0.15	0.58	0.02	1.00	0.53	0.70	0.23
Pinus halepensis Mill.	0.04	0.05	2.35	0.09	1.00	0.53	0.67	0.22
Vitex agnus-castus L.	0.04	0.05	1.40	0.05	1.00	0.53	0.64	0.21
Sapindus saponaria L.	0.04	0.05	1.27	0.05	1.00	0.53	0.63	0.21
Ficus microcarpa L.f.	0.04	0.05	0.93	0.04	1.00	0.53	0.62	0.21
Caesalpinia mexicana A.Gray	0.04	0.05	0.86	0.03	1.00	0.53	0.62	0.21
Tabebuia rosea (Bertol.) DC.	0.04	0.05	0.66	0.03	1.00	0.53	0.61	0.20
Prunus persica (L.) Batsch	0.04	0.05	0.59	0.02	1.00	0.53	0.61	0.20
Punica granatum L.	0.04	0.05	0.29	0.01	1.00	0.53	0.59	0.20
Citrus sinensis (L.) Osbeck	0.04	0.05	0.26	0.01	1.00	0.53	0.59	0.20
	75.43	100.00	2 611.31	100.00	187.00	100.0	300.0	100.00

*The species follow a decreasing order according to their importance value.

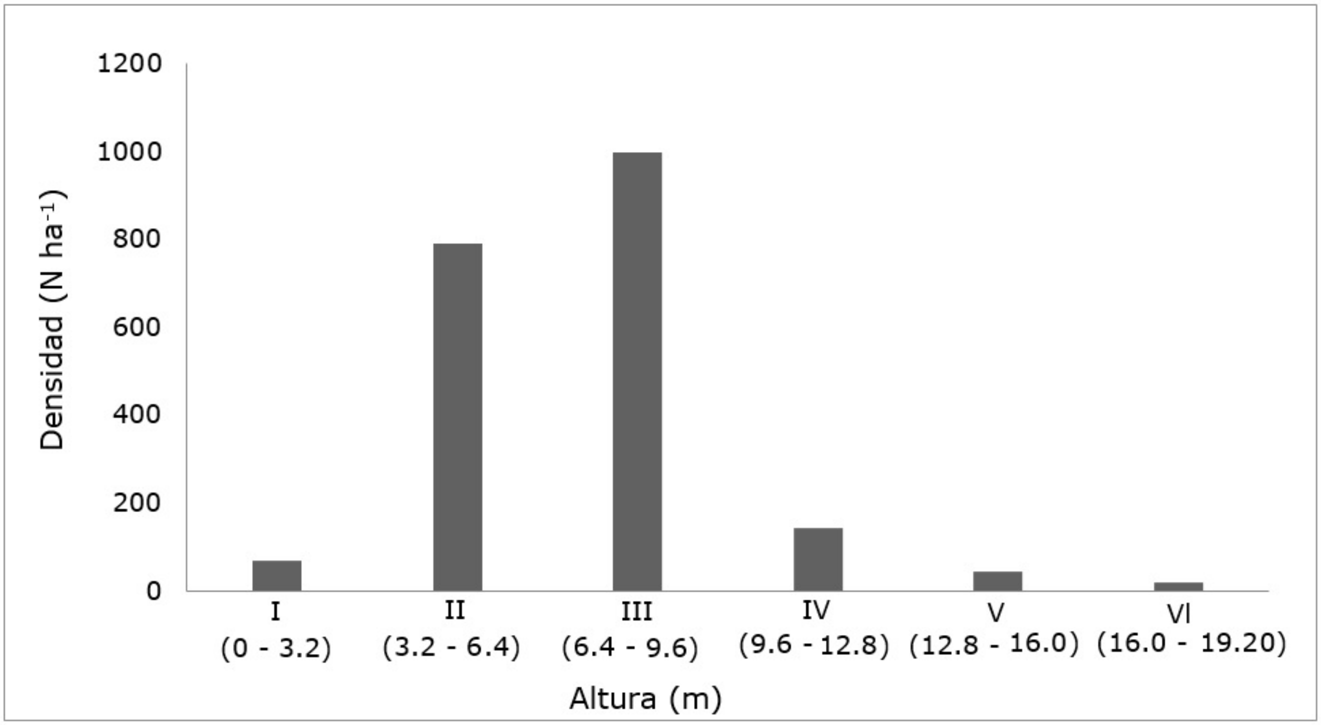
The density of individuals per hectare according to the diameter classes registered in the study showed that most of the individuals evaluated are concentrated in category II (14.5 - 29 cm) with a total of 1 011 N ha^{-1} (Figure 2).



Densidad = Density; *Clases diaméticas* = Diametric classes.

Figure 2. Density of individuals according to diametric classes in the study areas.

The mensuration variable of total height was calculated based on the density of individuals by height category. Category III (6.4 - 9.6 m) was the one that predominated with a total of 998 individuals per hectare, which corresponds to 48.3 % of all registered individuals, while category VI (16 - 19.2 m) was the lowest number of individuals with only 19 (0.91 %) (Figure 3).



Densidad = Density; *Altura* = Height

Figure 3. Density of individuals by height in the study area.

The evaluated area showed values of Margalef's Index of D_{Mg} = 5.24 and of Shannon-Wiener of H' = 1.99, and the val H'_{max} = 3.17.

Discussion

In the inventory of urban trees 2 066 specimens were registered, belonging to 24 families and 41 species. This number of species is close to the data of Zamudio (2001) in the center of *Linares*, who identified the existence of 39 species, with 19 families in 1995 and 49 species with 27 families in 1999. It is low compared to the study conducted by Alanís (2005), who in an investigation in the metropolitan area of Monterrey, detected 115 species, grouped in 37 families, which surely responds to the difference in the sampled surface.

On the other hand, Alanís *et al.* (2014) observed a similar number of species (39) to the one registered in this study, by restricting the area to the university campus of the Faculty of Forestry Sciences of the UANL.

The Fabaceae family was the best represented with six species (three native and three exotic), followed by Fagaceae with four species (three exotic), Moraceae with three species (two exotic), and Arecaceae with three species (all exotic). These data coincide with those of Alanís *et al.* (2014), who highlighted Fabaceae with 10 species (nine native). It also coincides with the information of Alanís (2005), in which Fagaceae and Moraceae are the most important in the Metropolitan Area of *Monterrey*.

The species with the greatest ecological weight for this study was *Fraxinus americana*, which concentrates 30.91 % of the Importance Value Index, followed by *Quercus virginiana, Carya illinoinensis, Whasingtonia robusta* and *Ligustrum japonicum* Thunb. This percentage is higher than that calculated by Alanís *et al.* (2014) who granted *Fraxinus americana* 18.21 % of IVI. Zamudio (2001) defined the latter within the four species with the greatest ecological weight (13.40 % of IVI).

In the study described here, dominant were *Fraxinus americana* (46.93 %), *Quercus virginiana* (21.14 %), *Carya illinoinensis* (9.79 %) and *Washingtonia robusta* (6.17 %). For Carabias and Herrera (1986), these percentages are not satisfactory, since they establish that no species should exceed 5 % of the total population in the public trees of a city.

Only 13 species are native (36.6 %) and 27 are exotic (63.4 %) (Table 2). The opposite is revealed by Alanís *et al.* (2014), since of its total number (39), 12 are exotic and 27 are native; this corresponds to a higher percentage of species of the second origin in the urban trees of the campus of the forest school. For the Metropolitan Area of *Monterrey*, Alanís (2005) accounted for 61 introduced species (53 %) and 54 native species (47 %).

The evaluated plant community has a species richness of D_{Mg} = 5.24 and a diversity of $H´$ = 1.99. These values are lower than those of Alanís *et al*. (2014), D_{Mg} = 7.62 and $H´$ = 3.05. When comparing the results observed in this research with those of Zamudio (2001) for diversity, for the year 1995 the value obtained was $H´$ = 2.54

and for the year 1999 it was *H´* = 2.27.

If the results of diversity and richness determined in the present investigation are contrasted only with the native species consigned by Alanís *et al.* (2014), it can be observed that these authors estimated high values of D_{Mg} = 5.80 and *H´* = 2.82, with respect to those here calculated of D_{Mg} = 2.12 and *H´* = 0.8127, which are lower.

Conclusions

The urban trees of the of Linares include a high number of exotic species; *Fraxinus americana*, *Quercus virginiana, Carya illinoinensis* and *Washingtonia robusta* var. *Gracilis* are dominant, the first one of which is the most representative with a total of 703 individuals, which are equivalent to more than 45 % of its green areas.

The actual research study revealed data about the number and surface areas of the squares, ridges and parks in the city of interest, as well as of the species and families of all the trees of the urban forest. This information is useful in the detection of priority areas for reforestation, as this is a reliable inventory that contributes to the management of public trees.

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Conflict of interests

The authors declare no conflict of interests.

Contribution by author

Carlos Eduardo Leal Elizondo: fieldwork, preparation of the manuscript regarding the summary, results and conclusions; Nelly Leal Elizondo: field work, elaboration of the manuscript regarding the summary, discussion and conclusions, design of figures and maps; Eduardo Alanís Rodríguez: preparation of the manuscript regarding the summary, introduction, results, discussion, conclusions and general review; Miguel Ángel Pequeño Ledezma: elaboration of the manuscript regarding the summary, abstract, introduction, discussion, conclusions, general review and application of corrections; Arturo Mora-Olivo: elaboration of the manuscript regarding the summary, introduction, discussion, conclusions, general review, application of corrections and identification of species; Enrique Buendía Rodríguez: preparation of the manuscript regarding the introduction, discussion and general review.

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