ISA International Society of Arboriculture

Arboriculture & Urban Forestry 2024. 50(4):286–300
https://doi.org/10.48044/jauf.2024.011

ARBORICULTURE & URBAN FORESTRY
Scientific Journal of the International Society of Arboriculture

A Tree-Prone Community: Residential and Street Tree Planting and Care in the Neotropical City of Xalapa, Mexico

By Ina Falfán, Martha Bonilla-Moheno, Luis-Bernardo Vázquez, and Ian MacGregor-Fors

Abstract. Background: Urban trees are the most conspicuous elements of greenery in cities, providing goods and services that contribute to people's well-being. However, proper tree care and management are necessary for their survival, particularly for street and residential trees. Methods: Through a survey, our objectives were to identify and quantify the presence of residential and street trees and the contribution of residents in tree planting and care in the city of Xalapa, Mexico. We assessed the dwelling characteristics that facilitate the presence, planting, and care of residential and street trees in the city (socioeconomic level, homeownership, time of inhabitance, and location of dwellings) via Generalized Linear Models. Results: In Xalapa, the presence of residential trees was higher than that of street trees; people contributed significantly to the planting and care of both residential and street trees; the socioeconomic level and time of inhabitance were positively associated with the presence and planting of street trees; and homeownership was positively associated with residential trees. However, tree care was largely independent of tree planting and dwelling characteristics. Conclusions: People's contributions and commitment to planting and care for residential and street trees are high, with the dwelling characteristics showing as important factors for tree presence and planting, but not for tree care. Recognizing people's actions and participation in tree planting and care and orienting them towards a positive impact through city planning and management can help to keep Xalapa as a green, functional city that provides quality benefits and services to the urban dwellers.

Keywords. Attitudes; Residents' Involvement; Urban Ecology; Urban Greening; Urban Trees.

INTRODUCTION

Urban greenery is an important component of cities and plays a crucial role in enhancing the quality of life of urbanites (Pickett et al. 2001; Forman 2014). It is distributed across public and private land, from remnant vegetation patches to parks, lawns, and gardens (Andersson et al. 2014). Trees, the most conspicuous elements of urban greenery (Pauleit 2003; McPherson et al. 2016), provide a range of benefits from social and cultural to environmental and economic (Tyrväinen et al. 2005; Nowak and Dwyer 2007; Roy et al. 2012). They store carbon and release oxygen, contribute to microclimate regulation, provide shelter and resources for urban wildlife, produce food, and constitute aesthetic spaces for educational and recreational activities, with positive impacts on physical and mental health (Rakhshandehroo et al. 2015; Bratman et al. 2019; Cox et al. 2019; Vogt 2020). Despite their numerous benefits, urban trees can also be perceived as a source of disservices, presenting challenges such as infrastructure damage, allergies, disease vectors, increased pollutant concentrations, and maintenance costs (Lyytimäki et al. 2008; Camacho-Cervantes et al. 2014; Delshammar et al. 2015).

In cities, trees undergo stressful conditions such as water scarcity, compact and impoverished soils, pollution, vandalism, pests and diseases, and the general consequences of climate change (Nowak et al. 1990; Tubby and Webber 2010; Steenberg et al. 2017; Esperon-Rodriguez et al. 2022). However, the preferences and decisions of people and local authorities can affect the health and condition of trees by influencing the characteristics of the tree community (e.g., cover, distribution, species composition and diversity)(Pauleit 2003; Kirkpatrick et al. 2012; Conway and Vander Vecht 2015; Vogt et al. 2015; Watkins et al. 2017).

©2024 International Society of Arboriculture

Since the main source of urban tree establishment is planting, tree survival and mortality are related to the tolerance of species and individuals to urban conditions; however, proper tree care, either by residents or local authorities, is a key factor in the prevalence of street and residential trees in cities (Gilbertson and Bradshaw 1985; Summit and McPherson 1998; Koeser et al. 2013; Roman et al. 2014; Vogt et al. 2015; Conway 2016; Roman et al. 2016; Smith et al. 2019).

Tree planting and care performed by people on residential lots and the streetscapes near their homes can be considered activities aimed at enhancing the experience of nature in urbanized environments (Whitburn et al. 2019; Oh et al. 2021; Cattivelli 2022) and represent a less expensive option for municipalities to green cities (Dean 2005). Nevertheless, implementing programs to engage people in residential tree planting can be challenging because of the diversity of individuals' attitudes, motivations, knowledge, and preferences regarding tree attributes, functions, and maintenance (Gilbertson and Bradshaw 1985; Summit and McPherson 1998; Conway 2016). Furthermore, street and residential tree planting and care have been associated with characteristics of individuals, households, and neighborhoods (e.g., gender, education, income, homeownership, length of residence, housing age, ethnicity), with contrasting results by region, city, or neighborhood, although often positively associated with women, homeowners, higher income, and higher education (Summit and McPherson 1998; Greene et al. 2011; Kirkpatrick et al. 2012; Donovan and Mills 2014; Watkins et al. 2017; Oh et al. 2021; Ibrahim et al. 2022).

Understanding the role of people as key promoters of urban tree planting and care activities, both on private and immediately adjacent public lands (Summit and McPherson 1998; Hunter and Brown 2012; Dilley and Wolf 2013; Conway 2016), provides valuable information for developing programs aimed at maintaining and enhancing greenery in cities (Summit and Sommer 1998; Greene et al. 2011). Our objective was to assess the actions carried out by the people in favor of local greening in Xalapa, a small-to-medium-sized Mexican city. For this, we aimed to identify and quantify (1) the presence of trees in the yards of residential lots (hereafter referred to as residential trees) and on the sidewalks in front of the dwellings (hereafter referred to as street trees), (2) people's contribution in the planting of residential and street trees, (3) people's commitment to residential and street tree care, and (4) the dwelling characteristics that facilitate the presence, planting, and care of trees in the city. As has been found for survival and mortality associated with tree planting and care (Nowak et al. 1990; Summit and McPherson 1998; Greene et al. 2011; Vogt et al. 2015), we expected that the presence, planting, and care of residential and street trees in Xalapa would be positively associated with higher socioeconomic level of dwellings, longer time of inhabitance, dwellings occupied by their owners, and dwellings located in neighborhoods rather than subdivisions. With this study, we aimed to contribute to the quantification and analysis of residents' tree planting and care in private and public spaces for Xalapa, a neotropical city for which, as for many Latin American cities, data and knowledge on urban forestry and urban greening by the population are largely unknown (Roy et al. 2012; Breuste 2013). To our knowledge, there is no previously published information on the presence, planting, and care of residential and street trees in Xalapa. While the information we provide here is at the local level, within a broader panorama, it contributes to an understanding of how people engage with urban greening in Latin America, and how greening practices compare to those of other urban areas with similar conditions in other regions of the world.

METHODS

Site Description

We carried out this study in Xalapa, a small-to-medium-sized city in central Veracruz, Mexico (Figure 1). The urban area of Xalapa covers approximately 64 km^2 and harbors approximately 550,000 inhabitants (INEGI 2021). Within an elevation range of 1120 to 1720 m above sea level (INEGI 2009), the climate of the city is humid semi-warm in the southeast and humid temperate in the northwest (Soto-Esparza and Gómez-Columna 1993). The geographical, natural, and social conditions gave rise to an important system of public and private green spaces (García-Campos 1993; Lemoine-Rodríguez et al. 2019). Xalapa is currently considered a 'green city', as its urban greenery covers more than one-third of its area (Falfán et al. 2018; Von Thaden et al. 2021). While the city is settled on the once-original vegetation of cloud forest and tropical dry forest and is surrounded by cloud forest fragments and agroecosystems (Castillo-Campos 1991; INEGI 2009), the current vegetation of Xalapa is composed of native and exotic species (García-Campos

©2024 International Society of Arboriculture

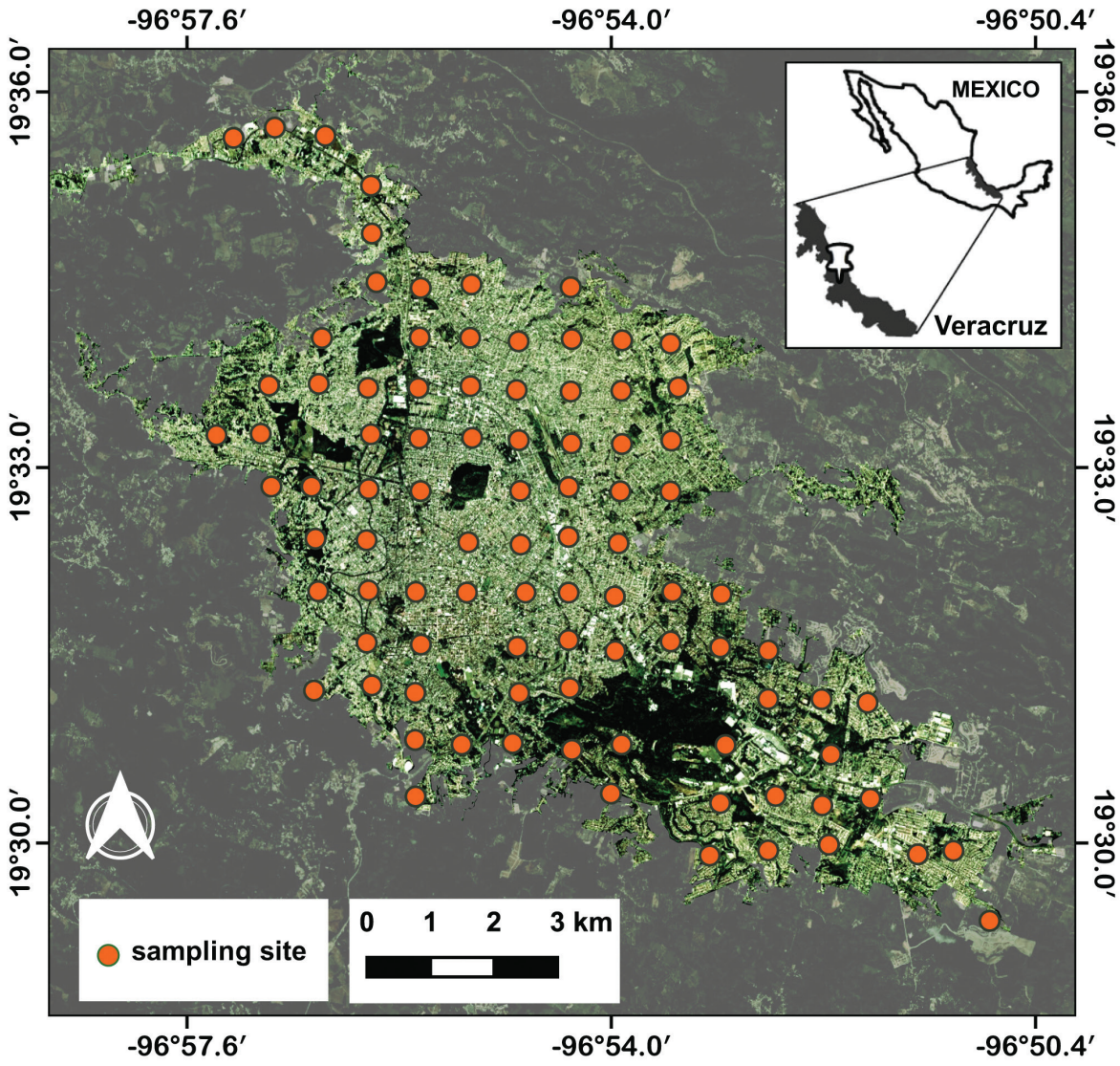

Figure 1. Location of Xalapa depicting the sampling scheme layout. Satellite imagery from Google Earth taken in 2023 February: at 2023 Maxar Technologies (Westminster, Colorado, USA), 2023 CNES/Airbus (Blagnac, France), and Landsat/Copernicus.

1993; Falfán and MacGregor-Fors 2016). As in many other cities worldwide (Avolio et al. 2018), tree planting is a common practice in Xalapa, performed mainly by residents in private spaces (e.g., home gardens, front yards, backyards), and by local authorities in public spaces (e.g., parks, streets, and median strips), according to reforestation plans and their attributions within the legal framework of the city (Castillo-Campos 1991; Garizurieta 2018; DMA 2022). The plants to be sown can be obtained from municipal and private nurseries and by way of personal propagation of cuttings and scions from specimens located in the city's green spaces. In Xalapa, urban tree care is the responsibility of both municipal authorities and citizens, according to local ordinances. This responsibility falls on citizens when trees are on private property or the front sidewalk of private property (GEV 2018), subject to certain regulations. For example, pruning of old or big trees requires permission from the competent authority, but pruning of shrubs or small trees for ornamental or aesthetic purposes does not require a permit. For urban tree removal, including those on private property, a signed permit must be obtained from the competent authority (AXV 2019).

©2024 International Society of Arboriculture

Data Collection

We developed a questionnaire of 15 items divided into 4 sections: (1) information about the respondents, (2) information about the dwellings, (3) trees inside residential lots, and (4) trees on the sidewalks in front of dwellings (Appendix 1). To check and improve our questionnaire's clarity, readability, feasibility, and suitability, we conducted a pilot test with 2 small samples of respondents similar to the target population. We obtained feedback from them on the difficulty, length, and format of our instrument and adjusted the wording, layout, and instructions, accordingly (Yusoff et al. 2021). We conducted interviews in dwellings throughout Xalapa, following a citywide sampling scheme (MacGregor-Fors 2019), which consisted of placing a 750 × 750 m point grid on a polygon of the city continuum, outlined following the criteria of building aggregation of and presence of communication paths according to MacGregor-Fors (2010) and Lemoine-Rodríguez et al. (2019). Points within the city polygon were relocated to the nearest accessible street if they fell into inaccessible locations. We considered only those points on streets of residential land use as final sampling sites, resulting in a total of 92 sampling sites (Figure 1). We collected information from 2 dwellings within a 100 m radius of each sampling site where residents agreed to answer the questionnaire, after first explaining the objectives of the survey. In 7 sampling sites (7.6 %), the residents of only 1 dwelling consented to participate. We surveyed a total of 177 dwellings. Since the respondents were the persons present in the dwelling at the time of the survey, over 16 years of age, who agreed to answer the questionnaire (i.e., only 1 respondent per dwelling, $n = 177$), no dwellings or respondents were selected a priori. We conducted all questionnaires face-to-face (i.e., a data collection method in which the interviewer asks questions through a questionnaire and the respondent answers these questions)(Loosveldt 2008), from August to October 2013. All respondents' participation was voluntary and confidential.

Data Analysis

To assess differences between the proportions of tree presence, planting, and care, we did 1- and 2-sample tests for equality of proportions with continuity correction, reporting χ^2 values. When the χ^2 assumptions were not met (mainly when one or more of the expected frequencies was less than 5)(Crawley 2013), we performed Fisher's exact test (which reports odds ratios [OR] and 95% confidence intervals [CI]). To test the relationships between the presence of residential and street trees and between tree planting and care practices, we performed a Pearson's chi-squared test with Yates' continuity correction. We assessed the relationship between the presence, planting, and care of residential and street trees (dependent variables) and dwellings' characteristics (independent variables) by using GLMs (generalized linear models) with a binomial error distribution considering an inverse logistic link function (i.e., "logit")(Hosmer and Lemeshow 2000; Crawley 2013). Dwellings' characteristics were (1) dwelling inhabited by homeowners (no, yes), (2) time of inhabitance in years, (3) location of dwelling in neighborhood or subdivision (in a neighborhood people buy a land lot and build their houses according to their preferences and financial possibilities; in a subdivision, builders divide the land into lots of similar size and build the houses according to the same design for eventual sale)(HAV 2018), and (4) socioeconomic level of the household (i.e., low, medium, high; using a categorical qualitative wealth scale based on house construction materials, facade condition, condition of surrounding urban infrastructure, and house size, following MacGregor-Fors and Schondube 2011). We ran the models for residential and street trees separately. We report χ^2 and p-values for the fitted models, as well as McFadden's pseudo-R^2 ($R^2_{\text{McFadden}} = 1 - \frac{LL_{mod}}{LL_0}$), where LL_{mod} is the log-likelihood value for the fitted model and LL_0 is the log-likelihood for the null model)(Hardin and Hilbe 2007; Gordon 2012). For the tree planting and care analysis, we assigned dwellings where respondents reported that some of the existent trees had been planted but some had not, proportionally to the observed frequencies; missing values were not considered. We performed all statistical procedures in R (Figure 2)(R Core Team 2019).

RESULTS

Respondents' and Dwellings' Characteristics

All respondents (n = 177; one per dwelling) were Mexican, from 17 to 86 years of age (average 47.1 ± 17.2 SD), and predominantly female (57.6%); males accounted for 36.7%, and 5.7% were missing data. The schooling degree of 67.8% of respondents was high school and lower; 22.5% had a bachelor's degree, 2.3% had a postgraduate degree, and only

©2024 International Society of Arboriculture

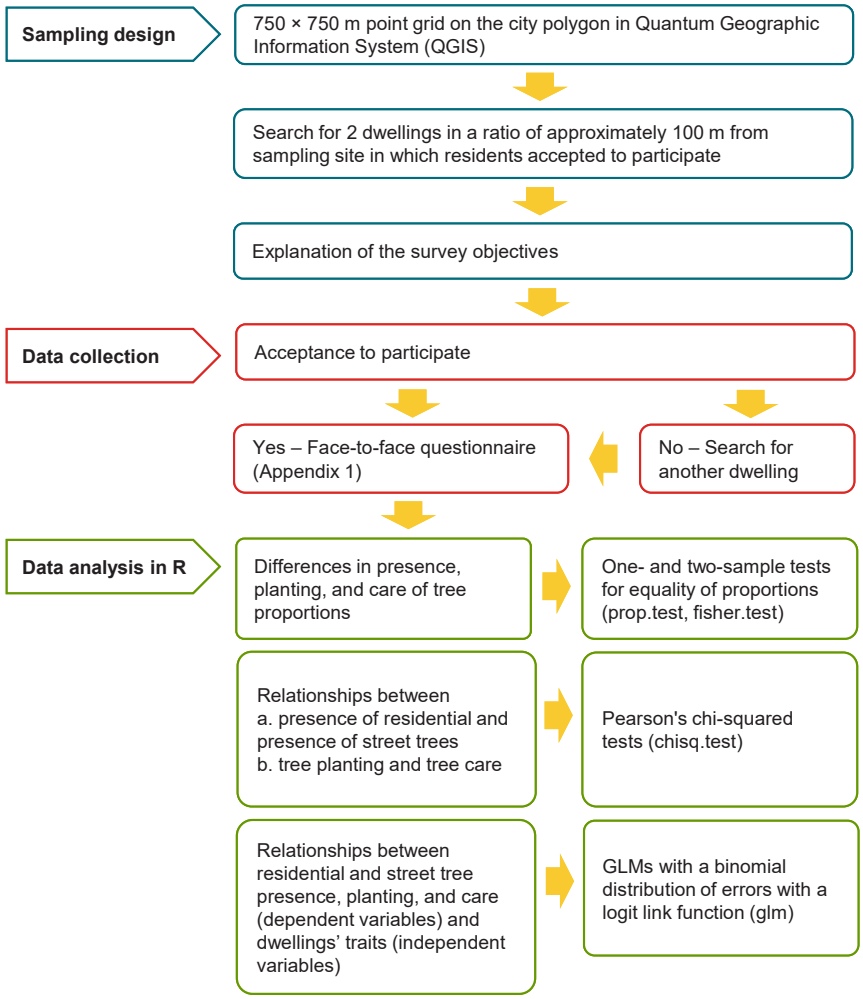

Figure 2. Methodological process for survey data collection and analysis.

5.1% had no schooling (2.3% of the data was missing). Half of the respondents (50.8%) were born in Xalapa, 33.4% in other urban and non-urban settlements of Veracruz State, and the remaining 15.8 % in other settlements in Mexico. The time that respondents had lived in Xalapa ranged from a few months to 80 years (average 30.9 ± 18.7 SD), with one-third having lived in Xalapa their entire lives. Of the surveyed dwellings, 78.5% were inhabited by their homeowners, with only one missing data (0.6%). Most of the dwellings (83.6%) were in neighborhoods, and a few (16.4%) were in subdivisions. At the time of the survey, the dwellings had been inhabited by their current residents for 0.02 to 69 years, with an average time of inhabitance of 18.7 ± 15.1 years.

Residential Tree Presence, Planting, and Care

Of the 177 dwellings surveyed, 52% were reported with the presence of trees, and 48% without trees, with no difference between these proportions ($\chi^2 = 0.203$, $df = 1$, $p = 0.652$). Of the dwellings where respondents reported having trees ($n = 92$), in 70.7% of them, residents planted the trees, while in 34.8% of dwellings did not (percentages equal > 100% due to respondents who indicated they planted some of the trees, but not all of them). In the latter case, previous residents planted the trees or were established naturally. Data showed a significant difference in proportions in favor of residential tree planting ($\chi^2 = 14.880$, $df = 1, p < 0.001$). Tree care occurred in most dwellings,

©2024 International Society of Arboriculture

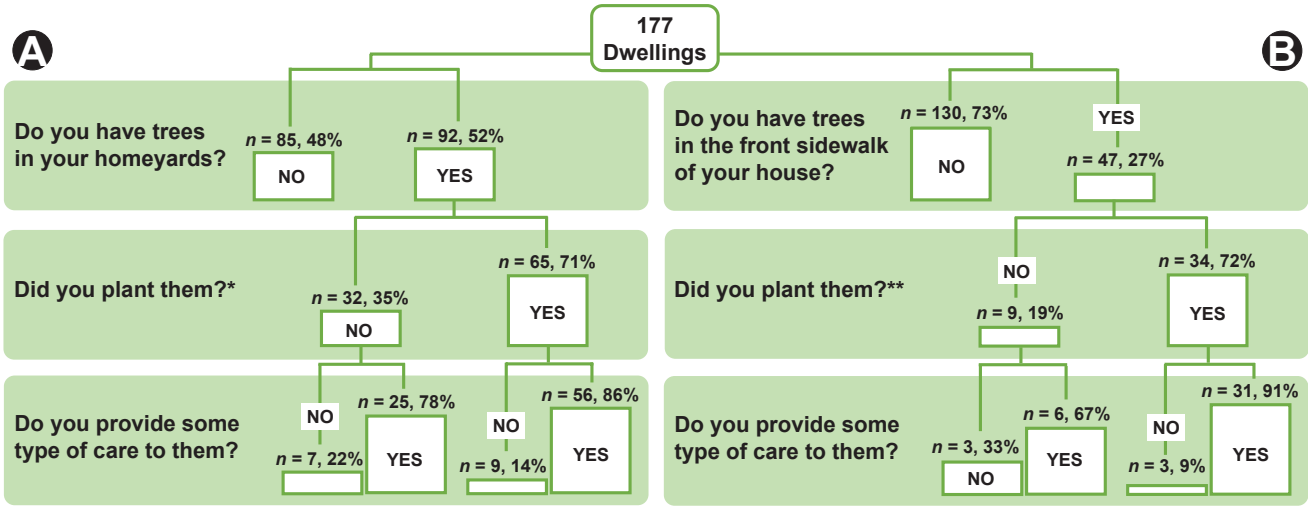

Figure 3. Diagram of presence, planting, and care percentages for (A) residential trees and (B) street trees in Xalapa. *Percentages sum up > 100% due to respondents who indicated they planted some of the trees in their homes, but not all of them. ** Percentages do not equal 100% due to four missing data.

whether residents planted the trees (86.2%) or not (78.1%), with no significant relationship between residents' tree planting and tree care (χ^2= 0.505, df = 1, p = 0.477). All these frequencies and percentages of the presence, planting, and care of residential trees across Xalapa are shown in Figure 3A. Tree care practices reported in 76 dwellings included pruning (n = 49; 64.5%), watering (n = 41; 53.9%), adding fertilizers or compost (n = 25; 32.9%), phytosanitary measures (e.g., insecticides, fumigation; n = 11; 14.5%), and cleaning and weeding (n = 8; 10.5%). Only one respondent (1.3%) reported that they "care" for their trees without further explanation (Figure 4).

Street Tree Presence, Planting, and Care

The presence of street trees on the sidewalks in front of the 177 surveyed dwellings was low; only 26.6% (n = 47) of the dwellings were reported to have tree presence, while 73.4% (n = 130) did not, representing significant differences between them (χ^2 = 37.989, df = 1, p < 0.001). Of the 47 dwellings with street trees, residents reported that they planted the existing trees in 72.3% of them. In 19.1% of the dwellings with street trees, residents did not plant the trees, showing significant differences (χ^2 = 8.511, df = 1, p = 0.004). We had missing data for 8.6% of the dwellings. Of the 34 cases where residents planted street trees, 91.2% reported caring for them, and 8.8% did not. Of the 9 dwellings where residents did not plant street

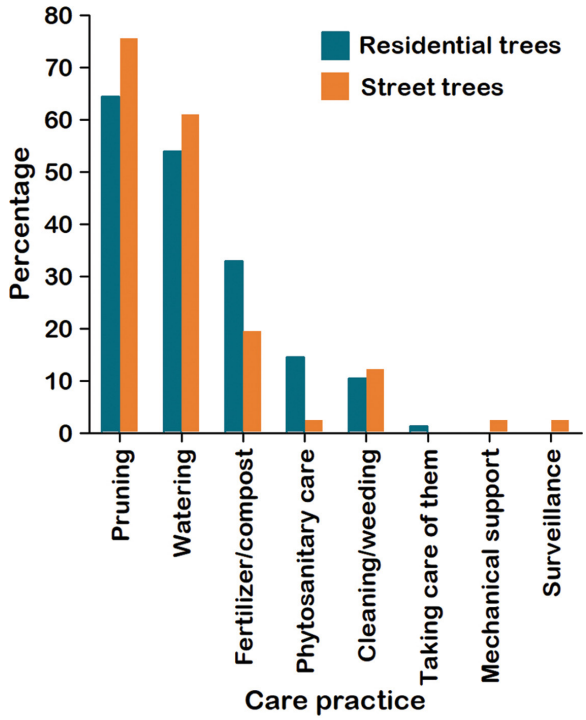

Figure 4. Reported care practices for residential and street trees in Xalapa. Percentages equal > 100% due to respondents that reported providing 2 and 3 types of care to trees.

trees, 66.7% cared for these trees, and 33.3% did not. Residents' care for street trees was higher when they planted them than when they do not, however, this difference was not significant according to Fisher's

©2024 International Society of Arboriculture

Table 1. Odds ratios from generalized linear models, with a binomial distribution of errors considering logit link function between presence, planting, and care of the residential and street trees and dwelling attributes in Xalapa.

		Dwelling attributes				Model fit parameters	
Attribute of analysis	**Type of tree**	**Homeowners (no, yes)**	**Years of inhabitance**	**Dwelling socioeconomic level (1, 2, 3)**	**Dwelling in neighborhood or subdivision**	**Likelihood ratio χ^2 (df = 4)**	**Pseudo R^2**
Presence	Residential	1.234	1.013	1.451	1.457	5.59	0.086
Presence	Street	0.835	1.035**	1.891*	1.751	13.15*	0.148
Planting	Residential	5.113*	1.019	0.699	1.679	10.56*	0.152
Planting	Street	1.572	0.992	1.023	0.238	2.49	0.159
Care	Residential	0.669	1.003	1.455	3.279	2.44	0.126
Care	Street	< 0.000	1.033	0.867	< 0.000	6.03	0.208

Significance level: * < 0.05, ** < 0.01.

exact test (p = 0.095; CI 95%: 0.530, 46.535) for an odds ratio of 4.9. The frequencies and percentages for the presence, planting, and care of street trees on the sidewalks in front of surveyed dwellings across Xalapa are in Figure 3B.

Of the 47 dwellings with street trees, most respondents (87.2 %; n = 41) reported providing care to the trees. The most frequent care practices reported for street trees were pruning and watering (> 50%), followed by adding fertilizer or compost, and cleaning and weeding (17.0% and 10.6 %, respectively). Phytosanitary care, provision of mechanical support, and surveillance were reported in only one dwelling each (Figure 4).

Residential and Street Tree Presence, Planting, and Care

We found a higher presence of residential trees than of street trees, with significant differences in the proportions (χ^2 = 22.933, df = 1, p < 0.001). We recorded a few dwellings with the presence of both residential and street trees (n = 23; 13.0 %), with no relationship between their presence (χ^2 = 0.100, df = 1, p = 0.752). Nonetheless, once given the presence of trees inside or in front of dwellings, the probability that those trees were planted was high and similar in both cases (χ^2 < 0.000, df = 1, p = 0.992). The proportion of dwellings where people cared for residential trees and the proportion of dwellings where they cared for street trees were similar (χ^2 = 0.213, df = 1, p = 0.645). Such a tree care affinity was maintained when considering the proportions of dwellings with planted residential and planted street trees only (OR = 0.605, p = 0.537, CI 95%: 0.098, 2.663). While the presence of trees was related to tree planting, tree care was not statistically related to tree planting (χ^2= 2.937, df = 1, p = 0.087). However, the frequencies of the reported care practices varied depending on whether the trees were street or residential, with street trees receiving comparatively more care and attention from residents than residential trees (Figure 4).

Relationship Between Presence, Planting, and Care of Trees and Dwelling Characteristics

Our results showed that the presence of residential trees, the planting of street trees, and the care of residential and street trees were largely independent of the evaluated dwellings' characteristics (socioeconomic level, time of inhabitance, home ownership, dwelling in neighborhood or subdivision). The presence of street trees was positively associated with the time of inhabitance and the dwellings' socioeconomic level. For each year increment in time of inhabitance, the probability of the presence of street trees increased only 1.03 times, while by 1 increase in socioeconomic level, the probability of street tree presence would be 1.89 times higher. Residential tree planting was positively related to dwellings inhabited by their homeowners and would be 5.11 times higher in dwellings occupied by homeowners than in the case where they were not (Table 1).

DISCUSSION

In cities, the planting and care of residential and street trees by people are necessary practices for tree presence, growth, and survival (Kirkpatrick et al. 2012; Roman et al. 2016). Our results showed that residents

©2024 International Society of Arboriculture

of Xalapa are important contributors to tree planting and are highly engaged in tree care on private and public property. Given the proportion of reported planted trees we found, our results were consistent with previous findings that the primary source of residential and street trees is planting rather than natural establishment (Roman et al. 2014; Avolio et al. 2018).

Residential and Street Tree Presence and Planting

The presence of residential trees was higher than the presence of street trees as has been shown for other cities in Australia, Canada, and the United States (Summit and McPherson 1998; Kirkpatrick et al. 2011; Sousa-Silva et al. 2023), highlighting the important role of residents as active agents of residential greenery. Contrary to the expected, the presence of street trees did not indicate much about the presence of trees in dwellings since the proportion of dwellings having both residential and street trees was low, with no relationship between the presence of both types of trees. Nevertheless, this absence of association could indicate different underlying processes in the presence of trees related to the private or public nature of the spaces, and to the stewardship type and stakeholders acting on each type of space (Kirkpatrick et al. 2011).

Residential and Street Tree Care

The performance of tree management practices indicates the people's interest in maintaining healthy, aesthetic, and safe trees (Summit and McPherson 1998). The diverse tree care practices performed by residents in Xalapa suggest their active involvement in the survival and aesthetic value of trees. Pruning was the most reported care practice for residential and street trees (Summit and McPherson 1998; Speak and Salbitano 2023), which is important to maintain their proper structure, help in their growth and aesthetics, and prevent branch fall (Badrulhisham and Othman 2016). Watering, the second most common reported care practice in the city, ensures access to water for both residential and street trees (Nowak et al. 1990). However, watering practice varies across climatic regions, being more frequent in hotter and drier regions (Locke et al. 2019). In Xalapa, although it rains year-round, there is a heatwave in the summer (Soto-Esparza and Gómez-Columna 1993), when watering is vital. Other less frequent care practices included adding fertilizer or compost, phytosanitary care, and cleaning and weeding, which had been also infrequent in other studies (Summit and McPherson 1998; Locke et al. 2019).

Tree Presence, Planting, and Care Related to Dwelling Characteristics

The results showed that the planting and care practices of residential and street trees were related to some dwellings' characteristics, although relationships varied according to the practice and the type of tree. In the case of residential trees in Xalapa, homeowners were active promoters of residential greening of the city, deciding what, why, when, and where to plant, which is consistent with what has been described in other cities (Summit and McPherson 1998; Acar et al. 2007; Marco et al. 2010; Dilley and Wolf 2013; Conway 2016; Guo et al. 2019; Danquah et al. 2023), with an impact on the tree species composition, diversity, and coverage (Kirkpatrick et al. 2012; Conway and Vander Vecht 2015; Avolio et al. 2018; Roman et al. 2018). Street tree presence was associated with dwellings' socioeconomic level, showing that Xalapa follows the trend already reported for other cities of generally more street trees in wealthier zones (Landry and Chakraborty 2009; Kirkpatrick et al. 2011; Li et al. 2015; Lockwood and Berland 2019). Since the socioeconomic level of dwellings was associated with street tree presence but not with street tree planting, it is plausible that their presence was more related to the planting efforts of municipal authorities rather than people (Kendal et al. 2012; Kirkpatrick et al. 2012). Furthermore, the low proportion of street trees on the sidewalks in front of the dwellings could indicate that efforts from local authorities have been oriented towards planting in public spaces such as parks and large avenues, rather than in neighborhood streets, as also shown in the calls for tree planting campaigns in the city (Garizurieta 2018; DMA 2022). This seems to be a generalized situation in cities (Pincetl et al. 2013), although some efforts have also been oriented toward private spaces (Perkins et al. 2004; Conway et al. 2022). The significant positive relationship of time of inhabitance only with street tree presence, linked to the lack of evidence of their association with street tree planting, as in Summit and McPherson (1998) for residential trees, could indicate a positive relationship between street tree presence and the age of the neighborhoods, as older neighborhoods are often reported to be greener (Grove et al. 2006; Lowry Jr. et al. 2012).

©2024 International Society of Arboriculture

Contrary to our expectations, tree care was not associated with dwellings' characteristics as reported in the literature (Grove et al. 2006; Roman et al. 2014; Locke et al. 2019). The lack of such associations shows that in Xalapa, residents are engaged in tree care in both public and private spaces regardless of ownership situation, socioeconomic level, time of inhabitance, and location of the dwelling in neighborhoods or subdivisions. According to the local ordinance, the care of trees is the responsibility of residents when they are on the sidewalk in front of private property (GEV 2018). However, based on our results, it seems that in Xalapa, residents care for trees because they want to, rather than out of obligation.

In terms of socioeconomic level, tree planting and care by people involve time and money investment, whether they do it themselves or hire people to do it for them (Summit and McPherson 1998; Dean 2005; Locke et al. 2019). This suggests a high level of commitment by Xalapa residents to their trees, including street trees for which residents often consider that their care is the responsibility of the government authorities (Moskell and Allred 2013). Limitations to tree planting and care of residential and street trees due to a lack of financial possibilities, support, or incentives (Pincetl et al. 2013) did not appear to be the case in Xalapa.

Limitations of the Survey

While residential and street tree planting and care practices appeared to be related to some of the dwellings' characteristics evaluated, it would be useful to evaluate the role of other dwelling, neighborhood, or individual attributes that we did not consider in this study, such as education, population density, age, or gender (Greene et al. 2011; Donovan and Mills 2014; Conway 2016; Watkins et al. 2017; Guo et al. 2019; Cattivelli 2022; Ibrahim et al. 2022; Danquah et al. 2023). At the individual level, we did not assess possible relationships between respondents' characteristics and residential and street tree planting and care in Xalapa, as has been done in other studies (Marco et al. 2010), because our respondents were not necessarily those who made the decisions regarding tree planting and care in the surveyed dwellings, the reason why we here focused only on dwelling characteristics.

Because we aimed to keep the questionnaire as short and simple as possible, we missed information from a more in-depth approach on residents' knowledge, possibilities, preferences, willingness, and motivations regarding residential and street tree care and planting. We did not record information on the number, species, or structure of the reported trees, which would have provided a richer context for tree planting and care in Xalapa. Finally, while our data were recorded ten years ago, to our knowledge, there is no previously published information on the presence, planting, and care of residential and street trees in Xalapa. Although the numbers may have changed, we provide valid and useful information to compare with current or future information on this topic for the city.

Implications for Urban Greening in Xalapa

It is important to develop local strategies to integrate the residents' willingness to plant and care for urban trees into greening programs and campaigns that motivate them also to continue planting and retaining their trees (Summit and McPherson 1998; Summit and Sommer 1998; Marco et al. 2010; Carmichael and McDonough 2018; Danquah et al. 2023). People's participation is an integral part of the overall strategy to use urban greenery and green space systems against climate change and to achieve sustainability and resilience in cities (Gill et al. 2007; Pitman et al. 2015). This strategy needs to be implemented at different scales within the city and with the collaboration of several stakeholders intervening at several levels of stewardship (Andersson et al. 2014; Breger et al. 2019). To implement these strategies, additional information is needed on motives, knowledge, and decisions behind people's tree preferences (Camacho-Cervantes et al. 2014; Speak et al. 2022), other tree planting and care practices (Cattivelli 2022; Ibrahim et al. 2022; Lange et al. 2022), as well as on aspects such as tree species composition, survival and mortality rates (Roman et al. 2014; Breger et al. 2019; Salisbury et al. 2022), frequency of care practices, and assessment of other household and individual characteristics (Marco et al. 2010; Ibrahim et al. 2022). This study is a first step toward a comprehensive understanding of how people's actions on private and public lands can impact the city's greenery for the benefit of the people themselves and the wildlife groups in Xalapa.

CONCLUSIONS

In Xalapa, the contribution of residents to tree planting, as well as their commitment to tree care on both private and public land, was high. Dwelling characteristics

©2024 International Society of Arboriculture

were important determinants of tree presence and planting, particularly, socioeconomic level and years of residents' stay, in the case of street trees, and home-ownership for residential trees. Tree care was largely independent of tree planting and dwelling characteristics. The overall commitment of the people of Xalapa to tree care was high and could be included in greening programs for public, private, and semi-private spaces. Furthermore, it would be useful for the city to encourage residents to retain or start, the planting and care of trees in their residential lots while facilitating them with information on the suitability of tree species to be planted according to the characteristics of the dwellings and their expectations and preferences for trees. Recognizing people's actions and participation in tree planting and care and orienting it towards a positive impact through city planning and management, can help to keep Xalapa as a green functional city that provides high-quality benefits and services to the city dwellers.

LITERATURE CITED

Acar C, Acar H, Eroğlu E. 2007. Evaluation of ornamental plant resources to urban biodiversity and cultural changing: A case study of residential landscapes in Trabzon city (Turkey). *Building and Environment*. 42(1):218-229. https://doi.org/10.1016/j.buildenv.2005.08.030

Andersson E, Barthel S, Borgström S, Colding J, Elmqvist T, Folke C, Gren Å. 2014. Reconnecting cities to the biosphere: Stewardship of green infrastructure and urban ecosystem services. *AMBIO*. 43(4):445-453. https://doi.org/10.1007/s13280-014-0506-y

Avolio ML, Pataki DE, Trammell TLE, Endter-Wada J. 2018. Biodiverse cities: The nursery industry, homeowners, and neighborhood differences drive urban tree composition. *Ecological Monographs*. 88(2):259-276. https://doi.org/10.1002/ecm.1290

Ayuntamiento de Xalapa, Ver. (AXV). 2019. Reglamento de conservación ecológica y protección al ambiente para el desarrollo sustentable del Municipio de Xalapa, Ver. [Accessed 2024 January 19]. https://xalapa.gob.mx/secretaria-del-ayuntamiento/normatividad

Badrulhisham N, Othman N. 2016. Knowledge in tree pruning for sustainable practices in urban setting: Improving our quality of life. *Procedia—Social and Behavioral Sciences*. 234:210-217. https://doi.org/10.1016/j.sbspro.2016.10.236

Bratman GN, Anderson CB, Berman MG, Cochran B, de Vries S, Flanders J, Folke C, Frumkin H, Gross JJ, Hartig T, Kahn PH, Kuo M, Lawler JJ, Levin PS, Lindahl T, Meyer-Lindenberg A, Mitchell R, Ouyang Z, Roe J, Scarlett L, Smith JR, van den Bosch M, Wheeler BW, White MP, Zheng H, Daily GC. 2019. Nature and mental health: An ecosystem service perspective. *Science Advances*. 5(7):eaax0903. https://doi.org/10.1126/sciadv.aax0903

Breger BS, Eisenman TS, Kremer ME, Roman LA, Martin DG, Rogan J. 2019. Urban tree survival and stewardship in a state-managed planting initiative: A case study in Holyoke, Massachusetts. *Urban Forestry & Urban Greening*. 43:126382. https://doi.org/10.1016/j.ufug.2019.126382

Breuste JH. 2013. Investigations of the urban street tree forest of Mendoza, Argentina. *Urban Ecosystems*. 16(4):801-818. https://doi.org/10.1007/s11252-012-0255-2

Camacho-Cervantes M, Schondube JE, Castillo A, MacGregor-Fors I. 2014. How do people perceive urban trees? Assessing likes and dislikes in relation to the trees of a city. *Urban Ecosystems*. 17(3):761-773. https://doi.org/10.1007/s11252-014-0343-6

Carmichael CE, McDonough MH. 2018. The trouble with trees? Social and political dynamics of street tree-planting efforts in Detroit, Michigan, USA. *Urban Forestry & Urban Greening*. 31:221-229. https://doi.org/10.1016/j.ufug.2018.03.009

Castillo-Campos G. 1991. *Vegetación y flora del municipio de Xalapa, Veracruz*. Xalapa (Veracruz, México): Instituto de Ecología. 148 p.

Cattivelli V. 2022. What motivations drive foreign gardeners to cultivate? Findings from urban gardening initiatives in Lombard municipalities. *Urban Forestry & Urban Greening*. 72:127511. https://doi.org/10.1016/j.ufug.2022.127511

Conway TM. 2016. Tending their urban forest: Residents' motivations for tree planting and removal. *Urban Forestry & Urban Greening*. 17:23-32. https://doi.org/10.1016/j.ufug.2016.03.008

Conway TM, Khatib JK, Tetreult J, Almas AD. 2022. A private tree by-law's contribution to maintaining a diverse urban forest: Exploring homeowners' replanting compliance and the role of construction activities in Toronto, Canada. *Arboriculture & Urban Forestry*. 48(1):9-26. https://doi.org/10.48044/jauf.2022.002

Conway TM, Vander Vecht J. 2015. Growing a diverse urban forest: Species selection decisions by practitioners planting and supplying trees. *Landscape and Urban Planning*. 138:1-10. https://doi.org/10.1016/j.landurbplan.2015.01.007

Cox DTC, Bennie J, Casalegno S, Hudson HL, Anderson K, Gaston KJ. 2019. Skewed contributions of individual trees to indirect nature experiences. *Landscape and Urban Planning*. 185:28-34. https://doi.org/10.1016/j.landurbplan.2019.01.008

Crawley MJ. 2013. *The R book*. Chichester (West Sussex, United Kingdom): Wiley. 1051 p.

Danquah JA, Pappinen A, Berninger F. 2023. Determinants of tree planting and retention behaviour of homeowners in built-up urban areas of Ghana. *Trees, Forests and People*. 13:100410. https://doi.org/10.1016/j.tfp.2023.100410

Dean J. 2005. "Said tree is a veritable nuisance": Ottawa's street trees 1869-1939. *Urban History Review*. 34(1):46-57. https://doi.org/10.7202/1016046ar

Delshammar T, Östberg J, Öxell C. 2015. Urban trees and ecosystem disservices–A pilot study using complaints records from three Swedish cities. *Arboriculture & Urban Forestry*. 41(4):187-193. https://doi.org/10.48044/jauf.2015.018

Dilley J, Wolf KL. 2013. Homeowner interactions with residential trees in urban areas. *Arboriculture & Urban Forestry*. 39(6):267-277. https://doi.org/10.48044/jauf.2013.034

©2024 International Society of Arboriculture

Dirección de Medio Ambiente (DMA). 2022. Plan de reforestación 2022. [Accessed 2023 July 09]. https://xalapa.gob.mx/medio-ambiente-y-sustentabilidad/wp-content/uploads/sites/32/2023/03/Plan-de-Reforestacion.pdf

Donovan GH, Mills J. 2014. Environmental justice and factors that influence participation in tree planting programs in Portland, Oregon, U.S. *Arboriculture & Urban Forestry*. 40(2):70-77. https://doi.org/10.48044/jauf.2014.008

Esperon-Rodriguez M, Tjoelker MG, Lenoir J, Baumgartner JB, Beaumont LJ, Nipperess DA, Power SA, Richard B, Rymer PD, Gallagher RV. 2022. Climate change increases global risk to urban forests. *Nature Climate Change*. 12(10):950-955. https://doi.org/10.1038/s41558-022-01465-8

Falfán I, MacGregor-Fors I. 2016. Woody neotropical streetscapes: A case study of tree and shrub species richness and composition in Xalapa. *Madera y Bosques*. 22(1):95-110. https://doi.org/10.21829/myb.2016.221479

Falfán I, Muñoz-Robles CA, Bonilla-Moheno M, MacGregor-Fors I. 2018. Can you really see 'green'? Assessing physical and self-reported measurements of urban greenery. *Urban Forestry & Urban Greening*. 36:13-21. https://doi.org/10.1016/j.ufug.2018.08.016

Forman RTT. 2014. *Urban ecology: Science of cities*. New York (NY, USA): Cambridge University Press. 462 p.

García-Campos HM. 1993. Las áreas verdes públicas de Xalapa. In: López-Moreno IR, editor. *Ecología urbana aplicada a la ciudad de Xalapa*. Xalapa (Veracruz, México): Instituto de Ecología p. 99-132.

Garizurieta H. 2018. En Xalapa inicia la campaña de arborización. *Agencia de Noticias RTV—Radiotelevisión de Veracruz*. [Updated 2018 July 9; Accessed 2021 February 24]. http://www.masnoticias.mx/en-xalapa-inicia-la-campana-de-arborizacion

Gilbertson P, Bradshaw AD. 1985. Tree survival in cities: The extent and nature of the problem. *Arboricultural Journal*. 9(2):131-142. https://doi.org/10.1080/03071375.1985.9746706

Gill SE, Handley JF, Ennos AR, Pauleit S. 2007. Adapting cities for climate change: The role of the green infrastructure. *Built Environment*. 33(1):115-133. https://doi.org/10.2148/benv.33.1.115

Gobierno del Estado de Veracruz (GEV). 2018. Ley de protección, conservación y fomento de arbolado y áreas verdes urbanas para el estado de Veracruz de Ignacio de la Llave. [Updated 2018 November 29; Accessed 2020 July 22]. 13 p. https://sisdti.segobver.gob.mx/siga/doc_gaceta.php?id=1814

Gordon RA. 2012. *Applied statistics for the social and health sciences*. New York (NY, USA): Routledge. 1080 p. https://www.routledge.com/9780415875363

Greene CS, Millward AA, Ceh B. 2011. Who is likely to plant a tree? The use of public socio-demographic data to characterize client participants in a private urban forestation program. *Urban Forestry & Urban Greening*. 10:29-38. https://doi.org/10.1016/j.ufug.2010.11.004

Grove JM, Troy AR, O'Neil-Dunne JPM, Burch Jr. WR, Cadenasso ML, Pickett STA. 2006. Characterization of households and its implications for the vegetation of urban ecosystems. *Ecosystems*. 9(4):578-597. https://www.jstor.org/stable/25470362

Guo T, Morgenroth J, Conway T. 2019. To plant, remove, or retain: Understanding property owner decisions about trees during redevelopment. *Landscape and Urban Planning*. 190:103601. https://doi.org/10.1016/j.landurbplan.2019.103601

H. Ayuntamiento de Veracruz, Ver. (HAV). 2018. Reglamento de desarrollo urbano, fraccionamiento y vivienda para el municipio de Veracruz, Veracruz. [Updated 2018 February 28; Accessed 2023 July 25]. https://gobiernoabierto.veracruzmunicipio.gob.mx/wp-content/uploads/2018/08/REGLAMENTO-DEL-INSTITUTO-MUNICIPAL-DE-VIVIENDA-DE-VERACRUZ.pdf

Hardin JW, Hilbe JM. 2007. *Generalized linear models and extensions*. College Station (TX, USA): Stata Press. 413 p.

Hosmer DW, Lemeshow S. 2000. *Applied logistic regression*. New York (NY, USA): John Wiley & Sons. 375 p.

Hunter MCR, Brown DG. 2012. Spatial contagion: Gardening along the street in residential neighborhoods. *Landscape and Urban Planning*. 105(4):407-416. https://doi.org/10.1016/j.landurbplan.2012.01.013

Ibrahim FM, Aderounmu AF, Akintola OO. 2022. Examining the socio-psychological predictors of tree-planting behaviour using the theory of planned behaviour: A study of a cohort of Nigerian urban workers. *Urban Forestry & Urban Greening*. 69:127509. https://doi.org/10.1016/j.ufug.2022.127509

Instituto Nacional de Estadística y Geografía (INEGI). 2009. Prontuario de información geográfica municipal de los Estados Unidos Mexicanos-Xalapa, Veracruz de Ignacio de la Llave-Clave geoestadística 30087. [Accessed 2023 September 11]. https://docplayer.es/60479-Prontuario-de-informacion-geografica-municipal-de-los-estados-unidos-mexicanos-xalapa-veracruz-de-ignacio-de-la-llave-clave-geoestadistica-30087.html

Instituto Nacional de Estadística y Geografía (INEGI). 2021. Censo de Población y Vivienda 2020. Microdatos para Veracruz de Ignacio de la Llave. [Accessed 2021 February 22]. https://www.inegi.org.mx/programas/ccpv/2020/#Microdatos

Kendal D, Williams KJH, Williams NSG. 2012. Plant traits link people's plant preferences to the composition of their gardens. *Landscape and Urban Planning*. 105(1-2):34-42. https://doi.org/10.1016/j.landurbplan.2011.11.023

Kirkpatrick JB, Daniels GD, Davison A. 2011. Temporal and spatial variation in garden and street trees in six eastern Australian cities. *Landscape and Urban Planning*. 101(3):244-252. https://doi.org/10.1016/j.landurbplan.2011.02.029

Kirkpatrick JB, Davison A, Daniels GD. 2012. Resident attitudes towards trees influence the planting and removal of different types of trees in eastern Australian cities. *Landscape and Urban Planning*. 107(2):147-158. https://doi.org/10.1016/j.landurbplan.2012.05.015

Koeser A, Hauer R, Norris K, Krouse R. 2013. Factors influencing long-term street tree survival in Milwaukee, WI, USA. *Urban Forestry & Urban Greening*. 12(4):562-568. https://doi.org/10.1016/j.ufug.2013.05.006

Landry SM, Chakraborty J. 2009. Street trees and equity: Evaluating the spatial distribution of an urban amenity. *Environment and Planning A*. 41(11):2651-2670. https://doi.org/10.1068/a41236

©2024 International Society of Arboriculture

Lange F, Hermans Z, De Koster J, Smismans R. 2022. Promoting pro-environmental gardening practices: Field experimental evidence for the effectiveness of biospheric appeals. *Urban Forestry & Urban Greening*. 70:127544. https://doi.org/10.1016/j.ufug.2022.127544

Lemoine-Rodríguez R, MacGregor-Fors I, Muñoz-Robles C. 2019. Six decades of urban green change in a neotropical city: A case study of Xalapa, Veracruz, Mexico. *Urban Ecosystems*. 22(3):609-618. https://doi.org/10.1007/s11252-019-00839-9

Li X, Zhang C, Li W, Kuzovkina YA, Weiner D. 2015. Who lives in greener neighborhoods? The distribution of street greenery and its association with residents' socioeconomic conditions in Hartford, Connecticut, USA. *Urban Forestry & Urban Greening*. 14(4):751-759. https://doi.org/10.1016/j.ufug.2015.07.006

Locke DH, Polsky C, Grove JM, Groffman PM, Nelson KC, Larson KL, Cavender-Bares J, Heffernan JB, Chowdhury RR, Hobbie SE, Bettez ND, Hall SJ, Neill C, Ogden L, O'Neil-Dunne J. 2019. Residential household yard care practices along urban-exurban gradients in six climatically-diverse U.S. metropolitan areas. *PLOS ONE*. 14(11):e0222630. https://doi.org/10.1371/journal.pone.0222630

Lockwood B, Berland A. 2019. Socioeconomic factors associated with increasing street tree density and diversity in Central Indianapolis. *Cities and the Environment*. 12(1):6. https://digitalcommons.lmu.edu/cate/vol12/iss1/6

Loosveldt G. 2008. Face-to-face interviews. In: de Leeuw ED, Hox JJ, Dillman DA, editors. *International handbook of survey methodology*. New York (NY, USA): Routledge. p. 201-220.

Lowry Jr. JH, Baker ME, Ramsey RD. 2012. Determinants of urban tree canopy in residential neighborhoods: Household characteristics, urban form, and the geophysical landscape. *Urban Ecosystems*. 15(1):247-266. https://doi.org/10.1007/s11252-011-0185-4

Lyytimäki J, Petersen LK, Normander B, Bezák P. 2008. Nature as a nuisance? Ecosystem services and disservices to urban lifestyle. *Environmental Sciences*. 5(3):161-172. https://doi.org/10.1080/15693430802055524

MacGregor-Fors I. 2010. How to measure the urban-wildland ecotone: Redefining 'peri-urban' areas. *Ecological Research*. 25(4):883-887. https://doi.org/10.1007/s11284-010-0717-z

MacGregor-Fors I. 2019. De mitos a hitos urbanos: ¿cómo hacer ecología en selvas de asfalto? In: Zuria I, Olvera-Ramírez AM, Ramírez Bastida P, editors. *Manual de técnicas para el estudio de fauna nativa en ambientes urbanos*. Querétaro (México): REFAMA, Universidad Autónoma de Querétaro. p. 19-38.

MacGregor-Fors I, Schondube JE. 2011. Gray vs. green urbanization: Relative importance of urban features for urban bird communities. *Basic and Applied Ecology*. 12(4):372-381. https://doi.org/10.1016/j.baae.2011.04.003

Marco A, Barthelemy C, Dutoit T, Bertaudière-Montes V. 2010. Bridging human and natural sciences for a better understanding of urban floral patterns: The role of planting practices in Mediterranean gardens. *Ecology and Society*. 15(2):2. http://www.ecologyandsociety.org/vol15/iss2/art2

McPherson EG, van Doorn N, de Goede J. 2016. Structure, function and value of street trees in California, USA. *Urban Forestry & Urban Greening*. 17:104-115. https://doi.org/10.1016/j.ufug.2016.03.013

Moskell C, Allred SB. 2013. Residents' beliefs about responsibility for the stewardship of park trees and street trees in New York City. *Landscape and Urban Planning*. 120:85-95. https://doi.org/10.1016/j.landurbplan.2013.08.002

Nowak DJ, Dwyer JF. 2007. Understanding the benefits and costs of urban forest ecosystems. In: Kuser JE, editor. *Urban and community forestry in the Northeast*. Dordrecht (Netherlands): Springer. p. 25-46. https://doi.org/10.1007/978-1-4020-4289-8_2

Nowak DJ, McBride JR, Beatty RA. 1990. Newly planted street tree growth and mortality. *Journal of Arboriculture*. 16(5):124-129. https://doi.org/10.48044/jauf.1990.032

Oh RYR, Fielding KS, Nghiem TPL, Chang CC, Shanahan DF, Gaston KJ, Carrasco RL, Fuller RA. 2021. Factors influencing nature interactions vary between cities and types of nature interactions. *People and Nature*. 3(2):405-417. https://doi.org/10.1002/pan3.10181

Pauleit S. 2003. Urban street tree plantings: Identifying the key requirements. *Proceedings of the ICE-Municipal Engineer*. 156(1):43-50. https://doi.org/10.1680/muen.2003.156.1.43

Perkins HA, Heynen N, Wilson J. 2004. Inequitable access to urban reforestation: The impact of urban political economy on housing tenure and urban forests. *Cities*. 21(4):291-299. https://doi.org/10.1016/j.cities.2004.04.002

Pickett STA, Cadenasso ML, Grove JM, Nilon CH, Pouyat RV, Zipperer WC, Costanza R. 2001. Urban ecological systems: Linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. *Annual Review of Ecology and Systematics*. 32:127-157. https://doi.org/10.1146/annurev.ecolsys.32.081501.114012

Pincetl S, Gillespie T, Pataki DE, Saatchi S, Saphores JD. 2013. Urban tree planting programs, function or fashion? Los Angeles and urban tree planting campaigns. *GeoJournal*. 78(3):475-493. https://doi.org/10.1007/s10708-012-9446-x

Pitman SD, Daniels CB, Ely ME. 2015. Green infrastructure as life support: Urban nature and climate change. *Transactions of the Royal Society of South Australia*. 139(1):97-112. https://doi.org/10.1080/03721426.2015.1035219

R Core Team. 2019. R: A language and environment for statistical computing. Vienna (Austria): The R Project for Statistical Computing. https://www.R-project.org

Rakhshandehroo M, Mohdyusof MJ, Tahirholder OM, Yunos MYM. 2015. The social benefits of urban open green spaces: A literature review. *Management Research and Practice*. 7(4):60-71.

Roman LA, Battles JJ, McBride JR. 2014. Determinants of establishment survival for residential trees in Sacramento County, CA. *Landscape and Urban Planning*. 129:22-31. https://doi.org/10.1016/j.landurbplan.2014.05.004

Roman LA, Battles JJ, McBride JR. 2016. *Urban tree mortality: A primer on demographic approaches*. Newtown Square (PA, USA): USDA, Forest Service, Northern Research Station. General Technical Report NRS-158. https://doi.org/10.2737/NRS-GTR-158

Roman LA, Pearsall H, Eisenman TS, Conway TM, Fahey RT, Landry S, Vogt JM, van Doorn NS, Grove JM, Locke DH,

©2024 International Society of Arboriculture

Bardekjian AC, Battles JJ, Cadenasso ML, van den Bosch CCK, Avolio M, Berland A, Jenerette GD, Mincey SK, Pataki DE, Staudhammer C. 2018. Human and biophysical legacies shape contemporary urban forests: A literature synthesis. *Urban Forestry & Urban Greening*. 31:157-168. https://doi.org/10.1016/j.ufug.2018.03.004

Roy S, Byrne J, Pickering C. 2012. A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. *Urban Forestry & Urban Greening*. 11(4):351-363. https://doi.org/10.1016/j.ufug.2012.06.006

Salisbury AB, Miesbauer JW, Koeser AK. 2022. Long-term tree survival and diversity of highway tree planting projects. *Urban Forestry & Urban Greening*. 73:127574. https://doi.org/10.1016/j.ufug.2022.127574

Smith IA, Dearborn VK, Hutyra LR. 2019. Live fast, die young: Accelerated growth, mortality, and turnover in street trees. *PLOS ONE*. 14(5):e0215846. https://doi.org/10.1371/journal.pone.0215846

Soto-Esparza M, Gómez-Columna M. 1993. Consideraciones climáticas de la ciudad de Xalapa. In: López-Moreno IR, editor. *Ecología urbana aplicada a la ciudad de Xalapa*. Xalapa (Veracruz, México): Instituto de Ecología. p. 81-98.

Sousa-Silva R, Lambry T, Cameron E, Belluau M, Paquette A. 2023. Urban forests—Different ownership translates to greater diversity of trees. *Urban Forestry & Urban Greening*. 88:128084. https://doi.org/10.1016/j.ufug.2023.128084

Speak AF, Montagnani L, Solly H, Wellstein C, Zerbe S. 2022. The impact of different tree planting strategies on ecosystem services and disservices in the piazzas of a northern Italian city. *Urban Ecosystems*. 25(2):355-366. https://doi.org/10.1007/s11252-021-01158-8

Speak AF, Salbitano F. 2023. The impact of pruning and mortality on urban tree canopy volume. *Urban Forestry & Urban Greening*. 79:127810. https://doi.org/10.1016/j.ufug.2022.127810

Steenberg JWN, Millward AA, Nowak DJ, Robinson PJ. 2017. A conceptual framework of urban forest ecosystem vulnerability. *Environmental Reviews*. 25(1):115-126. https://doi.org/10.1139/er-2016-0022

Summit J, McPherson EG. 1998. Residential tree planting and care: A study of attitudes and behavior in Sacramento, California. *Journal of Arboriculture*. 24(2):89-97. https://doi.org/10.48044/jauf.1998.012

Summit J, Sommer R. 1998. Urban tree-planting programs—A model for encouraging environmentally protective behavior. *Atmospheric Environment*. 32(1):1-5. https://doi.org/10.1016/S1352-2310(97)00175-1

Tubby KV, Webber JF. 2010. Pests and diseases threatening urban trees under a changing climate. *Forestry*. 83(4):451-459. https://doi.org/10.1093/forestry/cpq027

Tyrväinen L, Pauleit S, Seeland K, de Vries S. 2005. Benefits and uses of urban forests and trees. In: Konijnendijk CC, Nilsson K, Randrup TB, Schipperijn J, editors. *Urban forests and trees*. Berlin (Germany): Springer. p. 81-114. https://doi.org/10.1007/3-540-27684-X_5

Vogt J. 2020. Urban forests: Biophysical features and benefits. In: Goldstein MI, DellaSala DA, editors. *Encyclopedia of the world's biomes*. Elsevier. p. 48-57. https://doi.org/10.1016/B978-0-12-409548-9.12404-2

Vogt JM, Watkins SL, Mincey SK, Patterson MS, Fischer BC. 2015. Explaining planted-tree survival and growth in urban neighborhoods: A social–ecological approach to studying recently-planted trees in Indianapolis. *Landscape and Urban Planning*. 136:130-143. https://doi.org/10.1016/j.landurbplan.2014.11.021

Von Thaden J, Badillo-Montaño R, Lira-Noriega A, García-Ramírez A, Benítez G, Equihua M, Looker N, Pérez-Maqueo O. 2021. Contributions of green spaces and isolated trees to landscape connectivity in an urban landscape. *Urban Forestry & Urban Greening*. 64:127277. https://doi.org/10.1016/j.ufug.2021.127277

Watkins SL, Mincey SK, Vogt J, Sweeney SP. 2017. Is planting equitable? An examination of the spatial distribution of nonprofit urban tree-planting programs by canopy cover, income, race, and ethnicity. *Environment and Behavior*. 49(4):452-482. https://doi.org/10.1177/0013916516636423

Whitburn J, Linklater WL, Milfont TL. 2019. Exposure to urban nature and tree planting are related to pro-environmental behavior via connection to nature, the use of nature for psychological restoration, and environmental attitudes. *Environment and Behavior*. 51(7):787-810. https://doi.org/10.1177/0013916517751009

Yusoff MSB, Arifin WN, Hadie SNH. 2021. ABC of questionnaire development and validation for survey research. *Education in Medicine Journal*. 13(1):97-108. https://doi.org/10.21315/eimj2021.13.1.10

ACKNOWLEDGMENTS

The authors thank Montserrat Solano, Diego Osorio, Dalia Luna, and Leila García for their assistance with data collection. Ina Falfán acknowledges the scholarship provided by the National Council of Science and Technology (CONACYT, 344590) and the Doctoral Program of the Instituto de Ecología, A.C. (INECOL). This study was partially supported by the project "Patrones ecológicos y percepción social de la diversidad biológica que habita en la ciudad de Xalapa: Un enfoque multidisciplinario" of the Instituto de Ecología, A.C. (INECOL).

Ina Falfán
Red de Ambiente y Sustentabilidad
Instituto de Ecología, A.C.
Xalapa, Veracruz, México
Laboratorio de Restauración Ecológica
Instituto de Biología, Universidad Nacional Autónoma de México
Ciudad de México, México
0000-0002-8120-8326

Martha Bonilla-Moheno
Red de Ambiente y Sustentabilidad
Instituto de Ecología, A.C.
Xalapa, Veracruz, México
0000-0002-2403-2002

©2024 International Society of Arboriculture

Luis-Bernardo Vázquez
Ecology, Landscape, and Sustainability Group
Department of Observation and Study of the Earth, the Atmosphere and the Ocean
El Colegio de la Frontera Sur
San Cristóbal de las Casas, Chiapas, México
000-0002-1673-2455

Ian MacGregor-Fors (corresponding author)
Ecosystems and Environment Research Programme
Faculty of Biological and Environmental Sciences
University of Helsinki
Niemenkatu 73, FI-15140
Lahti, Finland
ian.macgregor@helsinki.fi
0000-0003-3198-7322

Conflicts of Interest:
The authors reported no conflicts of interest.

Résumé. Contexte: Les arbres urbains sont les éléments les plus visibles du verdissement dans les villes, fournissant des bénéfices et des services qui contribuent au bien-être de la population. Cependant, un entretien et une gestion adéquates des arbres sont nécessaires pour leur survie, particulièrement pour les arbres en bordure des rues et les arbres sur les terrains résidentiels. Méthodes: Par le biais d'un sondage, nos objectifs étaient d'identifier et de quantifier la présence d'arbres résidentiels et d'arbres de rue, ainsi que la contribution des résidents à la plantation et à l'entretien des arbres dans la ville de Xalapa, au Mexique. Nous considérons les caractéristiques des résidences qui facilitent la présence, la plantation et l'entretien des arbres résidentiels et des arbres de rue dans la ville (niveau socio-économique, statut de propriétaire ou non, période d'occupation des habitations et localisation des résidences) à l'aide de modèles linéaires généralisés. Résultats: À Xalapa, la présence d'arbres résidentiels était plus importante que celle d'arbres de rue; les gens contribuaient de manière significative à la plantation et à l'entretien des arbres tant résidentiels que sur rue; le niveau socio-économique et la période d'occupation de l'habitation étaient positivement associés à la présence et à la plantation d'arbres de rue tandis que le fait d'être propriétaire était positivement associé à la présence d'arbres résidentiels. Cependant, les soins apportés aux arbres sont largement indépendants des caractéristiques liées à la plantation et aux résidences. Conclusions: La contribution et l'engagement des gens à planter et à entretenir les arbres résidentiels et de rue sont élevés, alors que le fait d'être propriétaire ou non apparait comme un facteur important pour la présence et la plantation d'arbres, mais pas pour l'entretien des arbres. Reconnaître les actions et la participation de la population à la plantation et à l'entretien des arbres et l'orienter vers un impact positif sous l'angle de la planification et de la gestion municipale peut contribuer à faire de Xalapa une ville verte et fonctionnelle fournissant des bénéfices et des services de qualité aux résidents.

Zusammenfassung. Hintergrund: Stadtbäume sind die auffälligsten Elemente der Stadtbegrünung und tragen mit ihren Gütern und Dienstleistungen zum Wohlbefinden der Menschen bei. Für ihr Überleben ist jedoch eine angemessene Baumpflege und -bewirtschaftung erforderlich, insbesondere bei Straßen- und Wohnbäumen. Methoden: Mit Hilfe einer Umfrage wollten wir das Vorhandensein von Wohn- und Straßenbäumen sowie den Beitrag der Bewohner zur Anpflanzung und Pflege von Bäumen in der Stadt Xalapa, Mexiko, ermitteln und quantifizieren. Mit Hilfe von verallgemeinerten linearen Modellen wurden die Merkmale der Wohnungen untersucht, die das Vorhandensein, die Pflanzung und die Pflege von Wohn- und Straßenbäumen in der Stadt begünstigen (sozioökonomisches Niveau, Wohneigentum, Wohndauer und Lage der Wohnungen). Ergebnisse: In Xalapa waren mehr Wohnbäume als Straßenbäume vorhanden; die Menschen trugen in erheblichem Maße zur Pflanzung und Pflege sowohl von Wohn- als auch von Straßenbäumen bei; das sozioökonomische Niveau und die Dauer des Wohnsitzes wurden positiv mit dem Vorhandensein und der Pflanzung von Straßenbäumen in Verbindung gebracht; und der Besitz von Wohneigentum wurde positiv mit Wohnbäumen in Verbindung gebracht. Die Baumpflege war jedoch weitgehend unabhängig von der Bepflanzung und den Merkmalen der Wohnung. Schlussfolgerungen: Der Beitrag und das Engagement der Menschen bei der Anpflanzung und Pflege von Wohn- und Straßenbäumen ist hoch, wobei sich die Wohnungsmerkmale als wichtige Faktoren für das Vorhandensein und die Anpflanzung von Bäumen, nicht aber für die Baumpflege erweisen. Die Anerkennung des Handelns und der Beteiligung der Menschen an der Anpflanzung und Pflege von Bäumen und deren Ausrichtung auf eine positive Wirkung durch Stadtplanung und -management kann dazu beitragen, Xalapa als grüne, funktionale Stadt zu erhalten, die den Stadtbewohnern hochwertige Vorteile und Dienstleistungen bietet.

Resumen. Antecedentes: Los árboles urbanos son los elementos más conspicuos de la vegetación en las ciudades, ya que proporcionan bienes y servicios que contribuyen al bienestar de las personas. Sin embargo, el cuidado y el manejo adecuados de los árboles son necesarios para su supervivencia, especialmente para los árboles de las calles y residenciales. Métodos: A través de una encuesta, nuestros objetivos fueron identificar y cuantificar la presencia de arbolado residencial y vial y la contribución de los residentes en la plantación y cuidado de árboles en la ciudad de Xalapa, México. A través de Modelos Lineales Generalizados evaluamos las características de la vivienda que facilitan la presencia, plantación y cuidado del arbolado residencial y de la calle en la ciudad (nivel socioeconómico, propiedad de la vivienda, tiempo de habitabilidad y ubicación de las viviendas). Resultados: En Xalapa, la presencia de árboles residenciales fue mayor que la de árboles de calles; las personas contribuyeron significativamente a la plantación y cuidado de árboles tanto residenciales como de calle; el nivel socioeconómico y el tiempo de habitabilidad se asociaron positivamente con la presencia e instalación de árboles en las calles; y la propiedad de vivienda se asoció positivamente con los árboles residenciales. Sin embargo, el cuidado de los árboles resultó en gran medida independiente de la plantación de árboles y de las características de la vivienda. Conclusiones: las contribuciones y el compromiso de las personas con la plantación y el cuidado de los árboles residenciales y de la calle son altos, mostrándose las características de la vivienda como

©2024 International Society of Arboriculture

factores importantes para la presencia y plantación de árboles, pero no para su cuidado. Reconocer las acciones y la participación de las personas en la plantación y el cuidado de los árboles y orientarlos hacia un impacto positivo a través de la planificación y gestión de la ciudad puede ayudar a mantener a Xalapa como una ciudad verde y funcional que brinde beneficios y servicios de calidad a los habitantes urbanos.

Appendix.

Questionnaire on presence, planting, and care of residential and street trees in Xalapa, Mexico

Section 1. Respondent's information

1. Sex—Recorded as female or male.
2. Age—Recorded in years.
3. School level—Coded as: none (0), primary school (1), middle school (2), high school (3), vocational/technical school (4), university/bachelor's degree (5), postgraduate degree (6).
4. Place of birth—Recorded as nominal.
5. Time living in Xalapa—Recorded in years.

Section 2. Information regarding the dwelling

6. Type of dwelling—Recorded by us as dwelling in a neighborhood or subdivision.
7. Socioeconomic level of the dwelling—Recorded by us from 1 to 3.
8. Are you the owners of the dwelling?—Recorded as no or yes.
9. How long have you lived in the dwelling?—Recorded in years.

Section 3. Trees and shrubs in the dwelling

10. There are trees or shrubs in your dwelling?—Recorded as no or yes. If yes:
11. Did you plant them?—Recorded as no or yes.
12. What type of care do you provide them?

Section 4. Trees and shrubs on sidewalks in front of the dwelling

13. There are trees or shrubs on the sidewalk in front of your dwelling?—Recorded as no or yes.

If yes:

14. Did you plant them?—Recorded as no or yes.
15. What type of care do you provide them?

©2024 International Society of Arboriculture