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Original article

Diagnostic of urban trees in a section of Sancti Spíritus city

Diagnóstico del arbolado urbano en una sección de la ciudad de Sancti Spíritus

Diagnóstico da arborização urbana numa seção da cidade de Sancti Spíritus

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ABSTRACT

The current research was carried out with the aim of diagnosing the situation of the urban trees in a section of Sancti Spíritus city. For this, an area of 25.39 ha was selected, where three plots were established, in which the inventory and classification of tree species in terms of taxonomy, origin, uses, type of location, state of development and phytosanitary was carried out, unrest problems were identified, and the volume of wood

from those in the state of high trunk development was also estimated. In the studied section, 1 522 trees were counted, belonging to 59 species, 55 genera and 32 families, of which Fabaceae and Meliaceae were the best represented with 10 and 8 species respectively. *Casuarina equisetifolia* L. and *Hibiscus elatus* Sw. specified the largest number of individuals with more than 200 in each case. Timber species predominate (55.93 %), of which 722 examples are in high trunk development state, with an estimated volume of wood of 711.280 m^3 in general. 62.71% of the counted individuals are evergreen, and 49.16% correspond to autochthons species. Trees in groups predominate (63.4 %); 85.28 % have a good phytosanitary status while 61.76 % need some type of silvicultural care. The main problems identified were location of trees in compact soils; damage to infrastructures caused by root systems and proximity to electrical and telephone wiring. Finally, some measures are proposed to contribute to the improvement of the identified problems.

Keywords: Urban trees; Cassification; Conflictivity; Species; Running; Management; Planning.

RESUMEN

La investigación se realizó con el objetivo diagnosticar la situación del arbolado urbano en una sección de la ciudad de Sancti Spíritus. Para ello, se seleccionó un área de 25,39 ha donde se establecieron tres parcelas, en las que se realizó el inventario y clasificación de las especies arbóreas en cuanto a taxonomía, origen, usos, tipo de emplazamiento, estado de desarrollo y fitosanitario; se identificaron los problemas de conflictividad y estimó el volumen de madera de los ejemplares en estado de desarrollo fustal alto. En la sección estudiada, se contabilizaron 1522 árboles, pertenecientes a 59 especies, 55 géneros y 32 familias, de las cuales, Fabaceae y Meliaceae son las mejores representadas con diez y ocho especies respectivamente. La *Casuarina equisetifolia* L. e *Hibiscus elatus* Sw. presentaron el mayor número de ejemplares con más de 200 en cada caso. Predominan las especies maderables (55,93 %), de las cuales, 722 ejemplares se encuentran en el estado de desarrollo fustal alto, con un volumen de madera estimado de 711,280 m^3 en general. El 62,71 % de las especies son perennifolias, y el 49,16 % corresponde a especies autóctonas. Predominan los árboles en grupos (63,4 %); el 85,28 % presenta buen estado fitosanitario, mientras que el 61,76 % necesita algún tipo de atención silvicultural. Los principales problemas identificados fueron ubicación de árboles en suelos compactados; daños a infraestructuras provocados por los sistemas radiculares y la cercanía al cableado eléctrico y telefónico. Finalmente, se proponen un conjunto de acciones para contribuir al mejoramiento de los problemas identificados.

Palabras clave: Arbolado urbano; Clasificación; Conflictividad; Especie; Gestión; Manejo, Planificación.

RESUMO

A pesquisa foi desenvolvida tendo como objetivo de diagnosticar a situação da arborização urbana em um setor da cidade de Sancti Spíritus. Para tal, procedeu-se a elaboração de um inventário em três parcelas pré-estabelecidos numa área de 25,30 ha. As espécies arbóreas da área selecionada foram classificadas de acordo a taxonomía, uso, função, localização, estado de desenvolvimento e fitossanitário. Foram identificados problemas de conflito e estimado o volume de madeira dos espécimes em estado de alto

desenvolvimento do caule. Na seção estudada, foram contabilizadas 1.522 árvores, pertencentes a 59 espécies, 55 gêneros e 32 famílias, das quais Fabaceae e Meliaceae são as mais bem representadas com 10 e 8 espécies, respectivamente. *Casuarina equisetifolia* L. e *Hibiscus elatus* Sw. apresentaram o maior número de exemplares com mais de 200 em cada caso. As espécies madeireiras predominam (55,93 %), das quais 722 espécimes encontram-se em estado de alto desenvolvimento do caule, com volume de madeira estimado de 711.280 m^3 em geral. 62,71 % dos indivíduos contados são perenes, e 49,16 % correspondem a espécies autôctonas. Árvores em grupos predominam (59,46 %); 85,28 % apresentam bom estado fitossanitário enquanto 61,76 % necessita de algum tipo de cuidado silvicultural. Os principais problemas identificados foram a localização das árvores em solos compactados; danos a infraestruturas causados pelos sistemas radicais e proximidade de fiação elétrica e telefônica. Por fim, propõe-se um conjunto de medidas contributivas para a melhoria dos problemas identificados.

Palavras-chave: Árvores urbanas; Classificação; Conflito; Espécies; Gestão; Manejo; Planejamento.

INTRODUCTION

In mid-21st century, it continues to be a challenge for city managers and planners to ensure that cities are economically, socially and environmentally sustainable, resilient and capable of providing the ecosystem services required by citizens for a good quality of life.

According to FAO, (2017), urban and peri-urban forests can respond to this challenge because of their enormous contributions to environmental sustainability, economic viability and habitability of settlements, however, for that, they must be well managed and designed. In this sense, Duval *et al*., (2020) state that knowledge of the dynamics of the urban environmental system is essential to achieve these goals.

In the selection of suitable species for establishment in the urban area, it is necessary to take into account a series of factors such as, for example, the availability of space, soil conditions, environmental and social requirements of the dynamics of the city, as well as establishment and maintenance costs (Alvarado *et al*., 2014). In spite of the well-known benefits of urban trees in terms of ecological balance, by exercising regulatory and purifying functions of an environmental nature, sheltering and protecting fauna and flora, as well as guaranteeing an improvement in the quality of life of the citizens (Alonso *et al*., 2019); the establishment of tree species has different connotations with respect to the development of infrastructure, since in some cases, this can limit the development of plant species (Vargas 2020) or on the contrary, there may be species that affect the integrity of the infrastructure, generating situations of incompatibility that lead to deterioration or damage to them, or worse, put the safety of people or infrastructure at risk (Morales 2018).

Sancti Spíritus does not escape from this problem, and as in several Cuban cities, one can see in different areas, the planting of tree species without taking into account harmonization criteria between the requirements of the urban habitat and those of these plant species. The way in which urban trees are managed, as well as many of the design solutions adopted for their establishment, have a negative impact on their quality. Many areas that were originally conceived with spaces for trees currently show flaws in design,

planning and management that lead to the progressive deterioration of their image and limit not only their potential for use by the population, but also the important environmental function of trees in the city.

Based on the above, this research was developed with the objective of diagnosing the current state of urban trees in a section of Sancti Spíritus characterized by two of the most important recreational parks in the city.

MATERIALS AND METHODS

Location and generalities of the study

An area of 25.39 ha was selected for this research, which is located at coordinates 21p 55'35.09" N 79p 26'03.63" W. (Figure 1). Two of the city's most important recreational parks are located there: the Agricultural and Livestock Fair and the Provincial Zoo.

Figure 1. - Delimitation of the study area and establishment of the diagnostic polygons

The delimitation of the study section, as well as the determination of its area, was carried out using the Global Positioning System (GPS). Three (3) plots were established within the same area to facilitate the tours and recording of information; the criteria for the selection of these plots coincided with the work areas established by the Communal Services Company for the planting and care of urban trees in Sancti Spíritus, who normally use the term "block" to designate them.

The areas of each plot are:

- P-1= 6,02 ha
- P-2= 8,25 ha

- P-3= 11,12 ha

Both the Agricultural Fair, as well as the Zoological Park, was considered plots in all their extension. The zero point or starting point for the routes was set at the intersection between Avenida de los Mártires and Calle Telo Sánchez. Only areas in the state sector were worked on.

During the tours of the plots (field work), the direct visual inspection method was used to determine the following aspects:

- Type of location: this refers to the way in which the trees are established in the area; (palm grove, grove, trees in-group, isolated tree, alignment with flowerbeds, shaped trees, pruned hedge, and separator).
- Physical and sanitary condition of the specimens: this refers to the identification of trees with some type of damage to their external constitution (mechanical damage to trunks and/or branches, bifurcation, hollows, disease, necrosis).
- Need for silvicultural care: refers to the activities that should normally be carried out for the proper management of urban trees (partial or total pruning, extraction, application of mulch, soil decompaction).

Conflict problems: in this case, three types of risks were determined, assuming as such, those threats or vulnerabilities that can end in a serious event (Amézquita and Gavilán, 2020):

a) Risks that represent possible damage caused by trees due to different circumstances, which entail situations in which these affect infrastructures due to their own growth habits.

b) Risks that represent possible damage to trees, due to factors that may affect their normal development and quality of life.

c) Risks that represent possible damage to human beings, due to the weakening and breakage of trees, the excessive fall of leaves and flowers, or those that due to poor management or poor placement limit visibility on roads. In all these cases, they become the cause of problems or accidents that affect people in different ways.

Other activities developed during the tours were:

- Recording the common name of each of the individuals of arboreal size and counting the specimens present in each plot.
- Measurements of total height and diameter at 1.30 m to all specimens of timber species, for which a BLUME LEISS hypsometer and diametric tape were used respectively.
- Determination of the state of development: based on the dendrometric measurements taken.

The following aspects were determined by means of a desk study, using the method of consultation of bibliographic sources and specialized personnel, as well as reviews of herbarium materials:

- Taxonomic classification: up to species level.
- Origin: refers to the identification of autochthonous species (assumed as those that are believed to have arrived naturally in the country without human intervention, therefore, the opposite of introduced species) and exotic species (assumed as those foreign species that have been introduced into the country by humans, intentionally or unintentionally).
- Permanence of foliage: only two groups were assumed; evergreen and deciduous.
- Main use of the species: only timber, ornamental and fruit species were considered, and in the "other" category were species whose main use differs from those mentioned above, for example, medicinal and animal food. It should be noted that this classification was made on the basis of what is reflected in the specialized bibliography and not according to the function performed by the specimens studied in their area of location.

Several photographs and botanical samples were taken of the species not known to the authors for later identification.

From the dendrometric measurements taken and using Excel software (2016), the volume of wood in general, by species (timber) and by families was determined. The calculation was performed only for specimens in the high fustal stage of development because they are the most susceptible to being replaced during management activities; the following mathematical equation was used for this purpose (Equation 1).

$$V = \frac{\pi}{4}. d^2. h. f$$

Legend:
d= diameter (cm).
h= height (m).
f= shape coefficient.

RESULTS AND DISCUSSION

A total of 1522 specimens of arboreal bearing, belonging to 59 species, 55 genera and 32 families were recorded in the study section (Table 1).

Table 1. - Families and species present in the study area, with other relevant data

Family	Species (scientific name)	No. Of example.	Origin.	Evergreen	Main Use
Anacardiaceae	*Manguifera indica* L.	4	Ex	Perennif.	Fruit
Araliaceae	*Shefflera actinophylla* (Endl.) Harms.	6	Ex	Perennif.	Ornamental
Araucariaceae	*Araucaria angustifolia* (Bertol.) Kuntze.	3	Ex	Perennif.	Ornamental
Arecaceae	*Dypsis lutescens* (H. Wendl.) B. J. & J. D.	134	Ex	Perennif.	Ornamental
Bignoniaceae	*Tabebuia angustata* Britt.	67	Au	Caducif.	timber
	Spatodea campanulata P. Beauv.	4	Ex	Caducif.	Ornamental
	Crescentia cujete L.	5	Au	Perennif.	timber
Boraginaceae	*Cordia gerascanthus* (R. y P.) Cham.	1	Au	Perennif.	timber
	Cordia collococca L.	36	Au	Perennif.	Fruit
	Cordia dentata Jacq.	1	Au	Perennif.	Fruit
Caesalpinaceae	*Caesalpinea violácea (*Mill.) Standl.	22	Au	Perennif.	timber
Casuarinaceae	*Casuarina equisetifolia* (L.) Forst.	287	Ex	Perennif.	timber
Clusiaceae	*Calophyllum antillanum (*Britt.) Standl.	16	Au	Perennif.	timber
	Clusia rosea Jacq.	6	Au	Perennif.	timber
Combretaceae	*Terminalia catappa* L.	41	Ex	Caducif.	Fruit
Cupressaceae	*Juniperus lucayana* Britton.	10	Au	Perennif.	timber
Cycadaceae	*Cycas revoluta* Trunb.	3	Ex	Perennif.	Ornamental
Euphorbiaceae	*Hura crepitans* L.	2	Ex	Perennif.	Ornamental
	Aleurites moluccana (L.) Willd.	1	Ex	Perennif.	timber
Fabaceae	*Bauhinia variegata* L.	1	Ex	Caducif.	Ornamental
	Delonix regia (Bojer) Raf.	49	Ex	Caducif.	Ornamental
	Phyllocarpus septentrionales Donn. Sm.	1	Ex	Caducif.	Ornamental
	Albizzia lebbeck (L.) Benth.	35	Ex	Caducif.	Ornamental
	Samanea saman (Jacq.) Merrill.	38	Au	Perennif.	timber
	Leucaena leucocephala (Lam.) De Wit.	2	Ex	Perennif.	timber
	Tamarindus indica L.	2	Ex	Perennif.	Fruit
	Peltophorun ferrugineum Benth.	7	Ex	Caducif.	Ornamental

	*Gliricidia sepium (*Jac.) Kunth. y Walp.	1	Au	Caducif.	timber
	Lonchocarpus domingensis (Poir) DC.	1	Au	Perennif.	timber
Laminaceae	*Gmelina arbórea* Roxb.	21	Ex	Caducif.	timber
Lythraceae	*Lagerstrodermia speciosa* (L.) Pers.	4	Ex	Caducif.	Ornamental
Malvaceae	*Ceiba pentandra* (L.) Gaertn.	1	Au	Caducif.	timber
	Hibiscus elatus Sw.	241	Au	Perennif.	timber
Meliaceae	*Khaya nyasica* Stapf.	20	Ex	Perennif.	timber
	Khaya senegalensis Juss.	2	Ex	Caducif.	timber
	Cedrela odorata L.	24	Au	Caducif.	timber
	Trichilia hirta L.	1	Au	Perennif.	timber
	Guarea guidonia (L.) Sleumer.	4	Au	Perennif.	timber
	Swietenia macrophylla King.	127	Ex	Caducif.	timber
	Swietenia mahagoni (L.) Jacq.	5	Au	Caducif.	timber
	Azadirachta indica L.	7	Ex	Caducif.	timber
Moraceae	*Ficus spp*	32		Perennif.	Ornamental
Moringaceae	*Moringa oleífera* Lam.	2	Ex	Caducif.	Others
Myrtaceae	*Eucalyptus spp*	19	Ex	Perennif.	timber
	Psidium guajava L.	1	Au	Perennif.	Fruit
Palmaceae	*Cocos nucifera* L.	3	Ex	Perennif.	Fruit
	Coccothrinax crinita (G. & H. W. ex C. H. Wright) Becc.	1	Au	Perennif.	Ornamental
	Roystonea regia (Kunth) O. F. Cook	1	Au	Perennif.	Ornamental
Pinaceae	*Pinus caribaea* Morelet.	13	Au	Perennif.	timber
Polygonaceae	*Triplaris americana* (L.) Pav. ex Meisn	19	Ex	Caducif.	Ornamental
Proteaceae	*Grevillea robusta* A. Cunn. ex R. Br.	4	Ex	Perennif.	timber
Ramneaceae	*Colubrina arborescens* (Mill.) Sarg.	3	Au	Perennif.	timber
Rubiaceae	*Calicophyllum candidissimum* (Vahl.) DC	16	Au	Caducif.	timber
Rutaceae	*Citrus aurantium* L.	1	Ex	Perennif.	Fruit
Sapotaceae	*Chrysophyllum cainito* L.	1	Au	Perennif.	Fruit
Sterculiaceae	*Guazuma ulmifolia* Lam.	23	Au	Perennif.	timber
Urticaceae	*Cecropia screbeliana* L.	10	Au	Perennif.	timber
Verbenaceae	*Tectona grandis* Lf.	117	Ex	Caducif.	timber
	Vitex divaricata Urb.	13	Au	Caducif.	Ornamental

Legend: Ex= Exotic; Au= Autochthonous; Perennif. = evergreen; Caducif. = deciduous

From the information presented in the table above, the following aspects can be summarized:

Families with the highest number of species

In Figure 2, it is illustrated that the families Fabaceae, Meliaceae, Bignoniaceae, Boraginaceae and Palmaceae are the best represented in the study section according to the number of species (Figure 2).

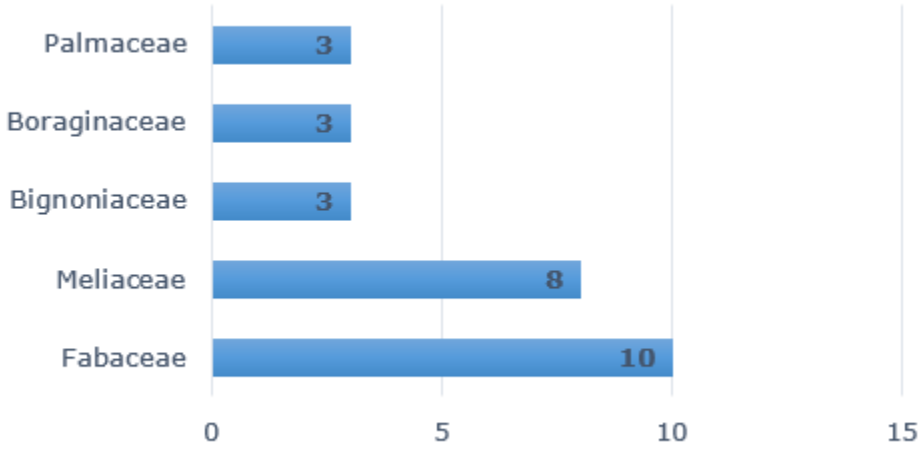

Figure 2. - Families represented by a higher number of species

These results are similar to those obtained by Machado *et al.,* (2016), who studied areas of heritage value in Santiago de Cuba and found a higher representativeness of the Fabaceae family with ten species. For their part, Leal *et al.*, (2018), in an area similar to the one selected for this study in Nuevo León, Mexico, recorded 2066 individuals, with greater representativeness for this same family.

Species with the highest number of specimens

As shown in Figure 3, *C. equisetifolia* and *H. elatus* were the species with the highest abundance of specimens with more than 200 in each case, followed by *D. lutescens*, *S. macrophylla* and *T. grandis*, with more than 100 each (Figure 3).

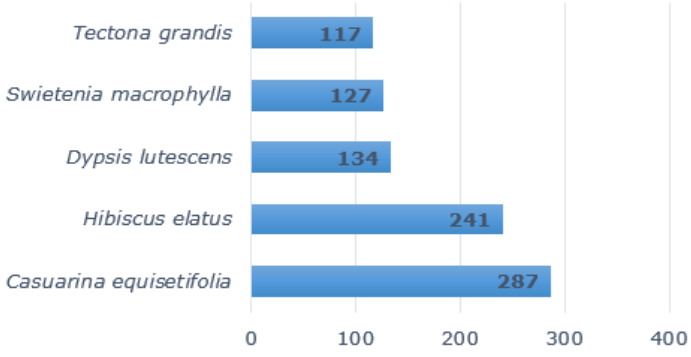

Figure 3. - Species with the highest abundance of specimens

The largest number of individuals corresponds to an exotic species (C. *equisetifolia*), considered by several authors as invasive, which also generally has a sparse crown and does not produce showy flowers, this species is more acceptable for the establishment of plantations for timber, energy and/or restoration purposes, especially in sites where open-pit mining is carried out, as it forms the soil. This result indicates planning problems, since urban tree plantations are often established based more on the availability of plants in nurseries, rapid growth and the great plasticity of some species than on the function they should perform in the places where they are located. *H*. *elatus*, a native species, has a good crown, showy flowers and is highly appreciated for its multiple uses, including medicinal, timber and ornamental uses.

Similar results were obtained by Bonilla-Vichot *et al.*, (2019) when they carried out studies in a section of the city of Pinar del Río, where they found an abundance of specimens of this species, while Sosa *et al*., (2011), carried out a similar investigation in the municipality of Guisa, Granma, and found a greater number of casuarina specimens in the area studied.

Classification of species by origin

Although the section selected for the study shows a balance between exotic species (50.84 %) and native species (49.16 %), the former are represented by a greater number of specimens with 928 (60.97 %). According to the results obtained in similar research at national (Sosa *et al*., 2011; Jiménez *et al*., 2015; Machado *et al*., 2016; Bonilla-Vichot *et al*., 2019) and international levels (Morales 2018; Leal *et al*., 2018), native species are less eligible when planning and managing urban tree planting; which is mainly due to the greater volume of information that exists on the management and propagation of exotic species, the plasticity of many of them, and their rapid growth.

Classification of the species by the permanence of the foliage

The 62.71 of the species present in the area are evergreen. For Urban Forestry it is important to take this aspect into account, since the placement of trees with such characteristics should be prioritized in places where their function is to provide shade, as well as in areas where the excessive leaf and flower fall typical of deciduous species could become a risk for passers-by.

Classification of species by their main use

Of the 59 species identified 55.93 % are timber; 28.81 % are ornamental; 13.55 % fruit and one species (1.71 %), *M. oleifera*, is primarily medicinal.

Currently, there is a tendency to enhance the establishment of fruit trees as part of urban trees, since, according to FAO, (2017), the presence of these species is very important; taking into account the role they can play in food sovereignty and security. On the other hand, considering that one of the areas studied is the Zoo, contemplating the planning of the establishment of fruit trees would have a significant impact as a nutritional supplement in the diet of the animals.

Other relevant information obtained in the study was as follows:

Trees per plot

- Plot number three presented the highest number of specimens with 932, followed by plots two and one, with 332 and 258 respectively.
- It was found that 9.13 % of the sections studied are stipitate trees.

Classification of the specimens according to their stage of development:

Of the 1 115 specimens belonging to timber species, it was found that 722 (64.75 %), are in high forest stage of development; 27.13 % in low forest; 6.01 % in sapling and 2.11 % in latizal.

It is important to observe the state of development of the trees located, since, as Matamoros, (2019) refers, the planning of pruning and other cultural attentions that will demand a greater number of resources as this is more advanced, which can greatly increase the cost of maintenance of urban areas, depends to a great extent on this. The importance of this aspect has also been highlighted by Carbajal, (2018), for whom the longevity of trees can become a high-risk factor if they are not well managed.

Dendrometric measurements

Diameter at 1.30 m in the studied tree stand ranged from 9 to 125 cm, while height values ranged from 3 to 21 m. These results are similar to those obtained by Sosa *et al*., (2011) in the city of Guisa, Granma province, who report diameters from 3.4 to 95 cm and heights from 1.5 to 25 m.

Estimated volume

The total estimated volume in the study section was 711.280 m^3. The families Casuarinaceae, Malvaceae, Verbenaceae and Meliaceae presented the highest values in the species *C. equisetifolia, H. elatus, T. grandis* and *S. macrophylla* respectively (Table 2).

Table 2. - Estimated wood volume values by species

Species	Families	Volume (m^3)
Casuarina equisetifolia	Casuarinaceae	190.219
Hibiscus elatum	Malvaceae	101.529
Tectona grandis	Verbenaceae	81.493
Swietenia macrophylla	Meliaceae	79.088

The behavior by plots was as follows:

- P-1 = 23.462 m^3; equivalent to 3,879 $m^3\ ha^{-1}$
- P-2 = 208.300 m^3; equivalent to 25,248 $m^3\ ha^{-1}$
- P-3 = 479.518 m^3; equivalent to 43,122 $m^3\ ha^{-1}$

The result is closely linked to the greater number of specimens of timber species present in the third plot, most of which are in an over-mature state.

Physical and health status

The tree mass studied is healthy, as 85.28 % of the specimens show no visible damage to their external constitution. Disease and mechanical damage to trunks and branches were observed in 8.67 % and 2.89 % of the individuals.

These results coincide with those of Sosa *et al*., (2011), Morales (2018) and Matamoros (2019), who found in their study areas most of the specimens with good physical and sanitary condition. Guerra *et al*., (2010) in areas of the city of Pinar del Río, found the most frequent damage to be mechanical, bark and diseases.

Despite the good condition of the stand, 940 trees, representing 61.76 %, require some type of silvicultural intervention, especially partial pruning and improvement of holes. These attentions are not only necessary to minimize risks, but also to improve the development conditions of the trees.

Classification according to the type of location

Group trees predominate (63.4 %), in which, *H*. *elatus*, *C*. *equisetifolia*, *T*. *grandis* and *S*. *macrophylla* are the most represented species. Isolated trees (21.41 %) and those aligned with flowerbeds (13.2 %) are the other most observed site types in the study section. This result is consistent with the presence in the study section of two recreational parks, and educational centers such as primary schools, children's circles, the Faculty of Agricultural Sciences of the UNISS among others.

Conflicts

The results of the conflictivity analysis and which in turn represent potential damage or risks are summarized below

Risks representing damage caused by trees

- Conflicts with electrical and telephone lines. This is a tree management problem in the area. It is mainly due to the fact that the established pruning is not carried out. Examples of species in this situation are *Eucalyptus* spp and *K*. *nyasica*.
- Conflict of root systems with sidewalks and roads. This is mainly due to planning problems, as large species with extensive root systems are observed to be located in limited spaces. Examples: *S*. *macrophylla*, *K*. *nyasica* and G. *arborea.*
- Conflict with infrastructures or construction works. These trees are located extremely close to buildings, which often causes problems of visibility and the inclination of the trunks. Example: *Sh*. *actinophylla.*

Risks such as those mentioned in this group, have been reported by Morales (2018); Bonilla *et al*., (2019); Amézquita and Gavilán (2020). While Ramos (2019), refers that these are the main problems or conflicts that occur in urban environments in most countries.

Risks that represent damage caused to trees

- Insufficient living space.
- Location in compacted soils.
- Mechanical damage to trunks and branches, generally caused by vandalism, and others caused by natural phenomena.

These types of risks have been cited in similar research by Guerra *et al*., (2010); Morales, (2018) and Matamoros (2019).

Risks that represent harm to humans

- Visibility. Refers to trees that interfere with the visibility of traffic lights or traffic signals, which can cause accidents. Specimens of the species *Ficus* spp and *T. angustata* present this type of risk in the area studied.
- Transit. This refers to species with excessive leaf and flower fall, located in areas with heavy foot traffic, which makes movement difficult. Specimens of the species *P. ferrugineum* were observed with this type of risk.

These types of conflicts have been mentioned as frequent in urban trees (Matamoros 2019 and Weisz 2020).

Recommended actions to eliminate or minimize the conflict problems identified in the study section

- Carry out the extraction and harvesting of specimens in high forest condition with a certain degree of conflict.
- Apply mulch to improve the structure and quality of the soil where the trees grow.
- Carry out soil decompaction to improve infiltration.
- Carry out the necessary pruning according to the degree of conflict and potential risks presented by the trees.
- Encourage the care and planting of fruit trees, as well as high carbon retaining species.
- Establish signage where necessary to encourage the care and protection of trees.
- Promote respect for the existence of trees and plantations established by restoration entities or builders of new works in the city.
- Establish educational strategies aimed at increasing the population's knowledge of the importance of urban trees.
- Increase the presence of endemic and native species.
- Replace over-mature trees, guaranteeing their use according to their main function.

- Update the Management Plan for the trees in the different sections of the city in accordance with the diagnoses made.

CONCLUSIONS

The urban trees in the section of the city of Sancti Spíritus selected for the study are abundant and diverse; their physical and sanitary condition is good, however, there are problems in terms of design, planning and management.

The families represented by a greater number of species are Fabaceae and Meliaceae; while *C. equisetifolia* and *H. elatus* present the greatest abundance of individuals.

Although there is a balance between the number of exotic and native species, the former are represented by a greater number of specimens.

In the study area there is an abundance of evergreen and timber species, which represents an advantage in terms of environmental services.

Through the study of site type, a predominance of trees in groups was determined, represented mainly by the species *H. elatus*, *C. equisetifolia*, *T. grandis* and *S. macrophylla*.

The conflict analysis made it possible to identify a group of risks that represent possible damage to infrastructures, to the trees themselves and to human beings; this led to the proposal of measures that not only make it possible to manage them, but also to outline communicative strategies that favor awareness on the part of the population.

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