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Article

Evaluación de la monumentalidad de árboles urbanos en México

Assessment of monumentality of urban trees in Mexico

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Resumen

La evaluación de los árboles monumentales es una actividad importante para promover su preservación. Según la revisión bibliográfica realizada, se encontró que, actualmente, no existe una legislación clara y suficiente en México para brindar protección a este tipo de individuos arbóreos. El objetivo de esta investigación fue evaluar la monumentalidad de árboles urbanos en México, con la participación de 15 expertos en el tema. Los ejemplares evaluados fueron: "El Tule"; "El Sabino"; "El Ahuehuete"; "La Higuera"; "El Baobab"; "El Ginkgo" y "El Árbol de los Acuerdos"; todos ellos ubicados en diferentes estados del territorio mexicano. Se definieron cinco criterios para la evaluación: tamaño del árbol, estado de conservación, importancia cultural, importancia del paisaje y rareza. El establecimiento de los criterios se basó en metodologías conocidas y utilizadas en la valoración de los árboles. El método *PROMETHEE* II se utilizó para determinar la monumentalidad. Los resultados del estudio indicaron que el "El Tule" y el "Árbol de los Acuerdos", localizados en el estado de Oaxaca y el Estado de México, respectivamente son los árboles que tienen características particulares que los hacen destacar sobre el resto de los individuos considerados en el estudio. El valor de monumentalidad más destacado fue para "El Tule", debido a que las evaluaciones de los expertos mostraron las preferencias más altas a favor del conjunto de atributos que lo caracterizan.

Palabras clave: Análisis multicriterio, árboles monumentales, árboles urbanos, catalogación de árboles singulares, evaluación de árboles, método *PROMETHEE II*.

Abstract

The evaluation of monumental trees is an important activity to promote their preservation. Based on the reviewed literature, there is currently no clear and enough legislation in Mexico to provide protection for them. The objective of this research was to evaluate the monumentality of some of the most iconic urban trees in the Mexican territory, which are located in different states. The specimens evaluated were *El Tule, El Sabino, El Ahuehuete, La Higuera, El Baobab, El Ginkgo* and *El Árbol de los Acuerdos*. Five criteria were defined for the evaluation: tree size, conservation status, cultural importance, landscape importance and rarity. The establishment of the criteria was based on known methodologies used in the valuation of the trees. The PROMETHEE II method was used to determine monumentality. The results of the study indicated that *El Tule*, located in the state of *Oaxaca*, and *El Árbol de los Acuerdos*, in the State of Mexico, have particular characteristics that stand out from the rest of the individuals considered in the study. The first one was graded with the greatest monumentality, based upon the highest preferences from its own attributes.

Keywords: Multi-criteria analysis, monumental trees, urban trees, cataloguing singular trees, evaluation of trees, PROMETHEE method.

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Introduction

Trees with special characteristics have been studied in most countries of the world. The interest in them is due to the fact that an important part of society considers them to be of great heritage, artistic, cultural, commercial, recreational and ecosystemic value (Gutiérrez, 2016). From the importance and interest in their conservation, various experts in the field define different concepts for cataloguing them. Such is the case of veteran trees (Lonsdale, 2015); champions (Ehrle, 2003); heritage trees (Cortés and León, 2017); significant trees (Sidney, 2013), and monumental trees (Çağlar, 2014; Asan, 2017), among others.

At present, there are countries such as Chile and Spain that propose the search for, and creation of legislative aspects as an instrument of protection for monumental or singular trees; other studies in the Iberian Peninsula are in charge of safeguarding genotypes of ancient olive trees in danger of extinction (Zapponi *et al.*, 2017; Villota, 2018). The concern for the preservation of special tree specimens arises because they represent a heritage, with scientific, artistic, cultural and commercial value, and also provide a service to the environment (Gutiérrez, 2016).

Based on the documentary review, it is observed that the regulation of special trees in Mexico is limited, and therefore an adequate legislative regulation is required to promote their preservation.

There are several studies on the monumentality of special trees, one of which is that of Asciuto *et al.* (2015), who carried out a survey using the Contingent Valuation Method among residents of households in Madonie Park (Sicily, Italy), to estimate the existence value of monumental trees on the nature trail called *Piano Sempria-Piano Pomo*, represented by a population of "Giant hollies" and seven other individual trees.

Some authors, such as Meza (2015), mention that studies on urban vegetation and, particularly on trees in Mexico, are scarce, address very heterogeneous topics; the vast majority have been carried out for Mexico City, and a few, for the city of *Monterrey.* On the other hand, the location of long-lived trees is primordial and

constitutes an additional element on which to base actions of protection, restoration of degraded ecosystems, as well as the formulation of ecotourism projects and conservation of biodiversity (Villanueva *et al.*, 2010).

Despite the contributions of the outstanding trees, they often face great survival challenges in the face of the imminent development of poorly planned urban projects, indiscriminate logging, lack of care and maintenance, vandalism and excessive tourism. Given the threats they face, it is important to highlight the care, conservation and protection of these trees as a natural and cultural heritage (Alanís and Ledezma, 2013).

There are specimens that have a series of special attributes in Mexico, which have made them a matter of interest for conservation over time. Although there is little information on this subject, one of the documented efforts is that of Vargas (1997), who made a compendium of historical and notable trees in Mexico, through a consultation collected with the participation of representative offices of the federal government. He thus obtained information regarding the presence of notable trees, which were classified into eight categories: notable tree, historical tree, notable and historical tree, undefined tree, notable grove, historical grove, notable and historical grove, and undefined grove. However, these are not described, nor are there criteria considered for their definition included.

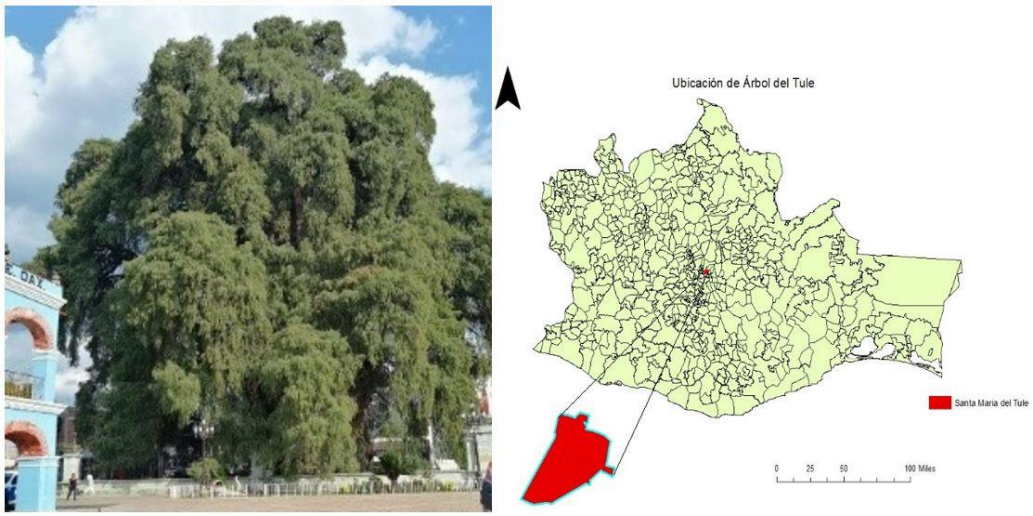
The objectives of the present investigation were to analyze and qualify the monumentality of seven trees considered for their special characteristics; for this purpose, a set of criteria associated with a set of important weights were determined through the PROMETHEE II method.

Materials and Methods

The trees included in this work are just a sample of the many specimens that could be evaluated. There is an extensive list of them in the country, which will meet most of the criteria that define their monumentality (Verástegui, 2013; Meza, 2015; Hernández, 2019). For research purposes, a set of trees that meet several of the following criteria were analyzed and agreed upon: a) Size of the tree, in which the height and circumference of the stem are considered; b) Conservation status, in which a value is assigned to the general status of conservation, based on the vigor, color and wilting of the foliage; c) Cultural significance, which is valued as a figure or natural element, linking the tree to history; d) Landscape significance, which refers to the landscape from the visual analysis that the tree offers to its surroundings; e) Rarity (scarcity) of the species, depending on the frequency of its occurrence in the environment.

The selected trees are located in different cities of the country and the description that follows is based, mainly, on the works of the *Instituto Nacional de Ecología y Cambio Climático* (National Institute of Ecology and Climate Change) (INECC) (2007) and Vargas (1997).

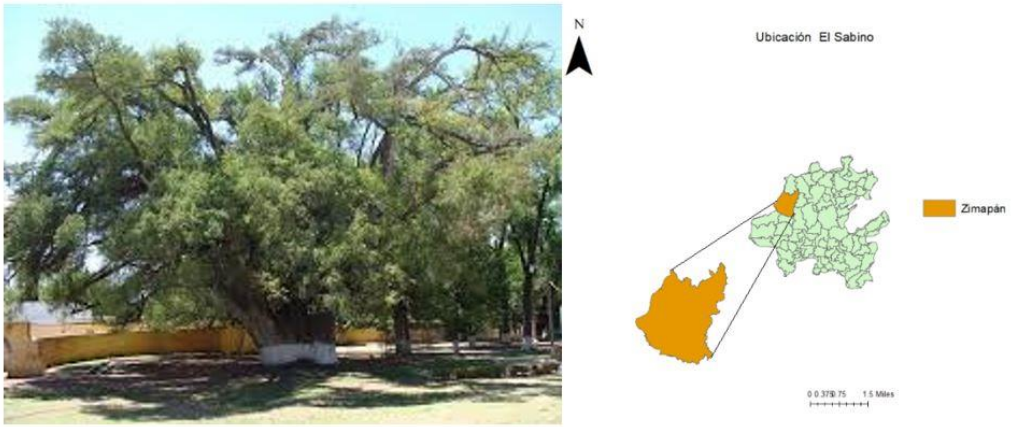
1. Tule tree: scientific name, *Taxodium mucronatum* Ten. It is located in the atrium of the *Santa María de la Asunción* church, in *Santa María del Tule*, *Oaxaca* (Figure 1). Its diameter at breast height (DBH) exceeds 14.36 m, and its height is 35.40 m. Among its relevant aspects, it is considered to be one of the trees with the largest trunk in the world and one of the oldest (aged more than 2 000 years). In 2003, the United Nations Educational, Scientific and Cultural Organization (UNESCO) declared it a World Cultural Heritage Site, and the *Secretaría de Medio Ambiente y Recursos Naturales* (Ministry of the Environment and Natural Resources) (Semarnat) recognized it is "The Most Remarkable Tree in the state of *Oaxaca*".



Prepared by the authors. Source: Conabio (2011).

Figure 1. *Tule* tree and its location.

2. *El Sabino*: scientific name, *Taxodium Mucronatum* Ten. It is located in *Zimapán, Hidalgo*, at *El Sabino* Park (Figure 2). Its DBH is 4.6 m, and its height is 25 m. In 1993, *El Sabino* was recognized by the National Institute of Ecology as the only Remarkable Tree in the state. It was used, according to different versions, for executing criminals during the time of the Mexican Revolution.



Prepared by the authors. Source: Conabio (2011).

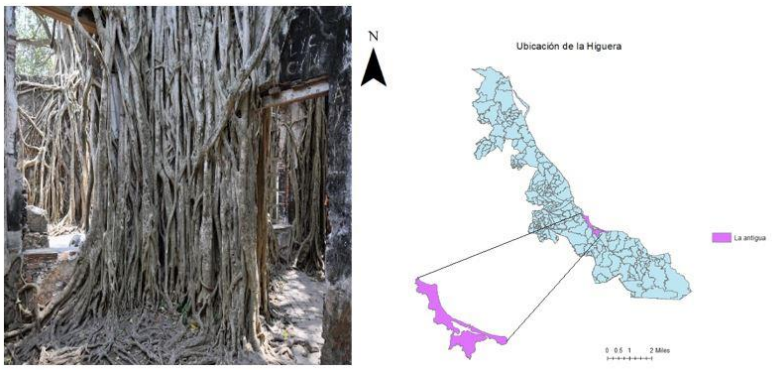
Figure 2. *El Sabino* tree and its location.

3. *El Ahuehuete*: scientific name, *Taxodium mucronatum* Ten., located in *Victoria de Durango*, at *El Guadiana* Park (Figure 3). Its DBH is 5.50 m, and its height is 9.10 m. It is the longest living *ahuehuete* in the *Guadiana* Park, with an approximate age of 200 years (Árboles Monumentales, 2013).

Prepared by the authors. Source: Conabio (2011).

Figure 3. *El Ahuehuete* and its location.

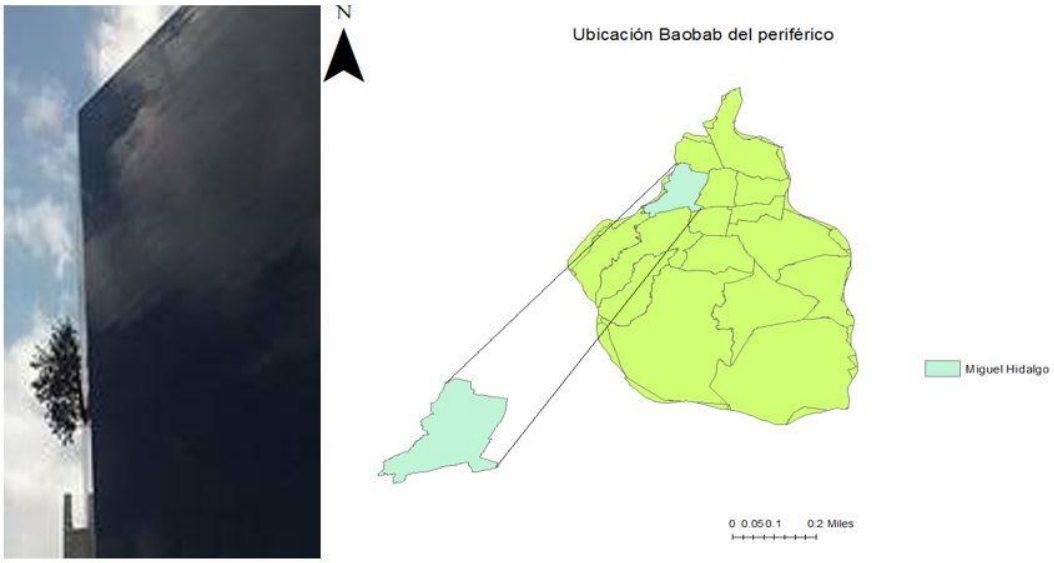
4. *La Higuera* (The Fig Tree): scientific name, *Ficus aurea* Nutt., located in *La antigua Veracruz*, Mexico (Figure 4). A relevant aspect, among others, is that it is located in the house that was owned by *Hernán Cortés*.



Prepared by the authors. Source: Conabio (2011).

Figure 4. *La Higuera* and its location.

5. The Baobab of the Mexico City freeway: scientific name, *Adansonia digitate* L., located on Bulevar *Manuel Ávila Camacho*, Mexico City (Figure 5). This tree was placed by Architect Víctor Lama, who decided to establish it in the windows of a ninth floor, in the frame of a very busy urban avenue. It was transplanted into a two-meter diameter pot for its survival, the interior of which contains more than a ton of soil. In order to meet the hydration needs of the *Baobab*, the pot has a mechanism, brought from Europe, which operates a watering system by means of a photocell.



Prepared by the authors. Source: Conabio (2011).

Figure 5. The Baobab and its location.

6. *Ginkgo*: scientific name, *Ginkgo biloba* L., is located at La *Bombilla* Park, *Álvaro Obregón* City Hall, Mexico City (Figure 6), with a DBH of 0.44 and a height of 18 m. It is believed that it was introduced by Engineer *Miguel Ángel de Quevedo*, the father of forest engineering in Mexico, who during a conference in the port of *Veracruz* mentioned that: "…in modern societies, forest conservation must be considered a necessary and obligatory function of the State." (Boyer, 2007).

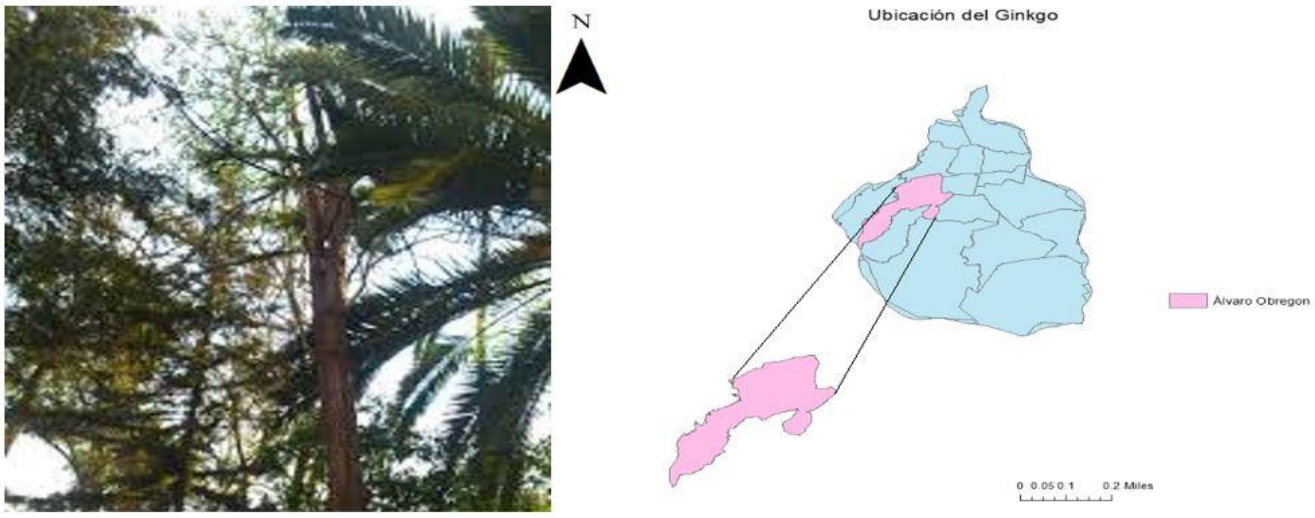


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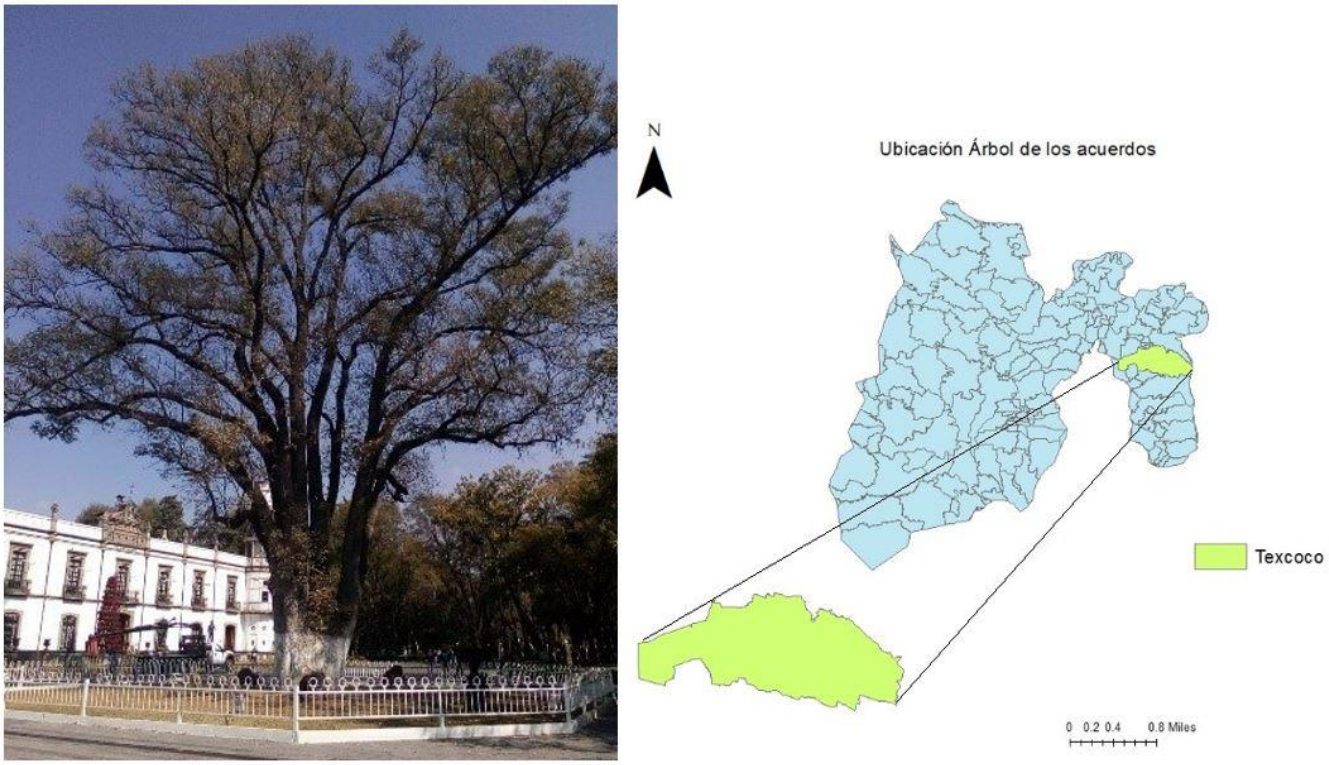
Figure 6. *Gingko* and its location.

7. *El Árbol de los Acuerdos* (Agreements Tree): scientific name, *Fraxinus udhei* (Wenz.) Lingelsh. This tree is located at the *Universidad Autónoma Chapingo* (Autonomous University of *Chapingo*) (Figure 7), with a DBH of 2.9 m and a height of 50 m. Under the shade of this tree, *General Manuel González*, who was the President of the Mexico, made some agreements. Later, it became the meeting place for the student community of the *Escuela Nacional de Agricultura* (National School of Agriculture), later he *Universidad Autónima Chapingo* (Autonomous University of *Chapingo*), for making agreements.



Prepared by the authors. Source: Conabio (2011).

Figure 7. *Árbol de los Acuerdos* (Agreements Tree) and its location.

The PROMETHEE method is one of several methods utilized to make Preference Ranking Organization Method for Enriched Evaluation (Brans and Vincke, 1985). It is one of the methods that use outranking relationships decisions about problems related to a set of alternatives rated according to a group of criteria.

This English acronym comes from the name between each pair of alternatives, based on the scores they record for each criterion or attribute. The PROMETHEE I method can provide a partial ranking of the decision alternatives, while PROMETHEE II produces a complete ranking of all the alternatives (Athawale and Chakraborty, 2010).

The literature records a very wide range of applications of the PROMETHEE method in different research fields. For example, the selection of airport locations (Palczewski and Salabun, 2019); the classification of districts by flood risk (Wendpanga, 2019); the evaluation of regeneration processes (Bottero *et al.*,

2018); comparison of alternatives in hydraulic structures (Brankovic *et al.*, 2018); the selection of best students (Fadlina *et al.*, 2017); the competence analysis and classification of industrial companies (Veza *et al.*, 2015); the selection of industrial equipment (Yilmaz and Dağdeviren, 2011), among many others.

The structure of the information used in PROMETHEE, as in any multi-criteria problem, generally consists of a matrix (Table 1) where $A = \{a_1, a_2, \dots, a_n\}$ is the set of alternatives, trees in our case; $C = \{c_1, c_2, \dots, c_m\}$ is the set of criteria, which in this problem are assumed to be maximized; and $c_i(a_j)$ is the evaluation of the alternative a_j based on the criterion c_i. It was assume that $c_i(a_j)$ is a numerical value.

Table 1. Structure of tree information.

$\boldsymbol{A}$	$\boldsymbol{c_1}$	$\boldsymbol{c_2}$	$\cdots$	$\boldsymbol{c_m}$
a_1	$c_1(a_1)$	$c_2(a_1)$	$\cdots$	$c_m(a_1)$
a_2	$c_1(a_2)$	$c_2(a_2)$	$\cdots$	$c_m(a_2)$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
a_n	$c_1(a_n)$	$c_2(a_n)$	$\cdots$	$c_m(a_n)$

In the present research, the PROMETHEE II method was applied by developing the following steps (Ishizaka and Nemery, 2013):

(1) Estimation of the degrees of preference, denoted by P_{ij}^c in each criterion c for each arranged pair of trees ij. Decisions on degrees of preference can be enriched by Preference functions; Brans and De Smet (2016) propose six to express them. This study utilizes the function known as usual [Figure 3, and equation (1); in which the values of the thresholds of indifference and preference are equal to zero. This means that, in the face of the slightest positive difference in $c_i(a_i) - c_i(a_j)$ the degree of preference is strong, equal to 1.; if the difference is negative or zero, the degree of preference is zero or indifferent.

$$P_{ij}^{c} = \begin{cases} 0 & si \quad c_i(a_i) - c_i(a_j) \leq 0 \\ 1 & si \quad c_i(a_i) - c_i(a_j) > 0 \end{cases} \qquad (1)$$

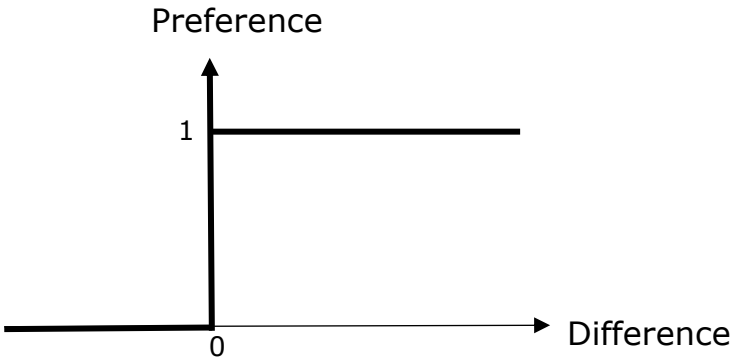


Figure 8. Usual preference function.

(2) Calculation of the positive, negative and unicriteria net flows. The positive flow indicates how a tree is preferred over all trees based on a particular criterion. Its estimation results from the following formula:

$$Positive\ flow = \frac{1}{n-1}\sum_{j=1}^{n} P_{ij}^{c}$$

Negative unicriteria flows measure how the other alternatives (trees) are preferred with respect to a particular alternative, this is given by:

$$Negative\ flow = \frac{1}{n-1}\sum_{i=1}^{n} P_{ji}^{c}$$

Net flows consider the positive and negative aspects of an alternative. They are obtained by subtracting the negative flow from the positive one. They represent the

balance between the strength and weakness of an alternative, and their value is always between -1 and 1.

(3) Estimation of the overall positive, negative and net flows, which consider all the criteria simultaneously. They are represented as:

$$Positive\ Global\ Flow = \Phi^{+}(a_i) = \frac{\sum_{j=1}^{n} \pi_{ij}}{n-1}$$

$$Negative\ Global\ Flow = \Phi^{-}(a_i) = \frac{\sum_{j=1}^{n} \pi_{ji}}{n-1}$$

Where:

π_{ij} = The "Global Preference Grades": This value represents the overall preference grades, taking into account the unicriteria preference grades and the weights (w_j) associated to every criterion, that is:

$$\pi(a_i.a_j) = \pi_{ij} = \sum_{c_1}^{c_n} w_j \cdot P_{ij}^{c}$$

The Global Net Flow is the difference between the Global Positive Flow and the Global Negative Flow.

For the analysis of the monumentality and the application of the method, data were collected from the seven trees selected with the participation of 15 experts (Table 2), whose average assessments were assumed to be consensus values.

Table 2. Characteristics of the panel of experts who participated in the evaluation.

Main Study Area	Number of Experts	Main Activity
Biology	7	Academy and Research

Silviculture	4	Academy and Arboriculture
Forest Restoration	2	Academy and Arboriculture
Ecology	2	Academy and Research

Most of the specimens were known to the experts; however, the assessments were supported by the display of recent photographs of the trees of interest. In rating the performance of the trees based on the various criteria, the experts expressed their assessments using a five-term linguistic scale, which was subsequently converted into a numerical one as follows: Very good, 4; Good, 3; Fair, 2; Bad, 1, and Very bad, 0. The weighting of the criteria was estimated with the distribution of 100 points among them, according to the importance given to each criterion. Estimates for the application of the *PROMETHEE II* method were made using the Smart Picker Pro-version 4.1.0© software (Smart Picker, 2019).

Results

The assessments expressed by the experts for each tree in each criterion are shown in Table 3. On a first inspection of the data, as is usually the case with multi-criteria problems, it can be seen that none of the trees have the best scores for all the criteria considered. The weights assigned to each criterion were as follows: Size = 0.3; State of Conservation = 0.15; Cultural Significance = 0.3; Landscape Significance = 0.15, and Rarity = 0.1.

Table 3. Evaluation results.

Tree	Size	Conservation Status	Cultural Significance	Landscape Significance	Rarity
Árbol del Tule	3.00	2.73	2.67	2.93	2.67
El Sabino	2.50	2.40	1.40	2.53	2.60
El Ahuehuete	2.00	2.87	2.20	1.73	2.67
La Higuera	2.00	3.07	2.33	2.33	2.47
El Baobab	2.00	2.53	2.47	1.40	2.67

Ginkgo	2.00	2.73	2.07	1.73	2.73
Árbol de Los Acuerdos	3.00	2.67	2.53	2.29	2.27

The calculation of the degree of preference of one over the others (P_{ij}^{c}), as well as the degree of preference of the others in relation to each particular tree (P_{ji}^{c})) (Table 4). The estimate of the overall net flow defined the individual position of the specimens evaluated (Table 5).

Table 4. Unicriterion net flows.

Tree	Size	Conservation Status	Cultural Significance	Landscape Significance	Rarity
Árbol del Tule	0.833	0.167	1.000	1.000	0.333
El Sabino	0.333	-1.000	-1.000	0.667	-0.333
El Ahuehuete	-0.500	0.667	-0.333	-0.500	0.333
La Higuera	-0.500	-0.667	0.333	-1.000	0.333
El Baobab	-0.500	0.167	-0.667	-0.500	1.000
Ginkgo	0.833	0.167	1.000	1.000	0.333
Árbol de Los Acuerdos	0.833	-0.333	0.667	0.000	-1.000

Table 5. Global Flows.

Tree	Positive Flow	Negative Flow	Net Flow	Position
Árbol del Tule	0.825	0.067	0.758	1
Árbol de Los Acuerdos	0.625	0.325	0.300	2
La Higuera	0.417	0.433	-0.017	3
El Ahuehuete	0.300	0.492	-0.192	4
El Baobab	0.275	0.542	-0.267	5
El Sabino	0.358	0.642	-0.283	6
Ginkgo	0.250	0.550	-0.300	7

Discussion

The results show that only two trees exhibit positive values in the Net Global Flow (*Tule* Tree, Agreements Tree). This indicates that, considering the set of criteria that determine the monumentality, they are the most preferred in comparison with the rest of the trees.

Based on the above, we observe that the best evaluated, and consequently the most monumental tree, based on the Net Global Flow (0.758, Table 5), was the *Tule* Tree. In its rating, two criteria had the best performance, expressed in the value of their net flows unicriteria corresponding to Cultural Significance and Landscape Significance. However, the influence of the first was greater because of the weight of the criterion (0.3); while, the influence of the second was lower because of its lower weight (0.15). The contributions of both criteria to the monumentality of the *Tule* Tree are expressed in the colors green and brown, respectively (Figure 4). The influence of the criterion Size had a unicriterial net value of 0.833 (Table 3), which, multiplied by its assigned weight of importance (0.3), was 0.25, in orange (Figure 4). In this case, the contribution of all the criteria was positive.

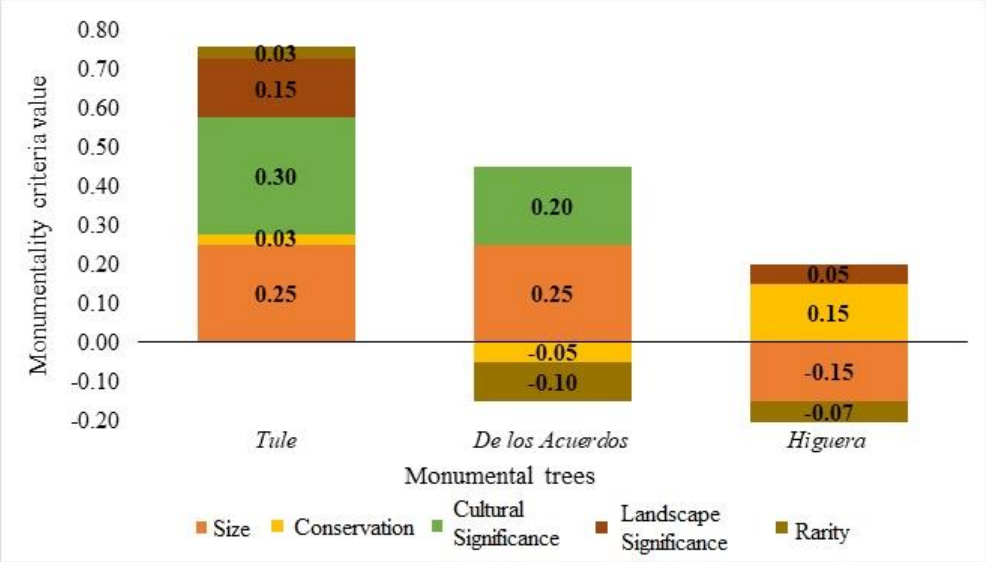


Figure 4. Trees with the best rating in monumentality.

Figure 4 shows only the three trees with the best rating in monumentality. The second tree with the highest monumentality rating was the Agreements Tree, whose highest criterion was Size (0.25). Likewise, negative contributions are observed in the criteria: Conservation Status (-0.05) and Rarity (-0.1), which means that in both criteria, the average sum of the preferences of the rest of the trees, with respect to the Agreements Tree, was higher. Even though this tree occupies the second place, its monumentality value (0.30) is very distant from that of the *Tule* Tree (Figure 4).

La Higuera recorded a negative monumentality value, very close to zero, although it is in third position. This is explained by the negative contribution of two criteria: Size (-0.15), and Rarity (-0.067).

The rest of the trees had negative Global Net Flow which indicates very low degrees of preference in the paired comparisons made by the experts, between the different trees for each of the criteria, which resulted in negative monumentality values.

There are very few documented examples of the evaluation of special trees, and what applies is the weighted sum of the assessments in the alternatives. One such

study is that of Villota (2016) conducted in the historical territory of *Álava*, Spain, in which a list was generated and ordered from the highest to the lowest importance of uniqueness of the trees evaluated. It is important to note that there is no study in the literature on the evaluation of trees using the PROMETHEE method, which demonstrates the importance of this study.

Conclusions

The monumentality of the trees studied is well suited to the application of multi-criteria analysis methods in general, and the PROMETHEE II method in particular.

Within the framework of the research, the two trees with the greatest monumentality are the *Tule* Tree and the Agreements Tree. For the *Tule* Tree, all its characteristics are evaluated positively, but it is most prominent in Cultural Significance, Landscape Significance, and Size. On the other hand, the Agreements Tree is also rated outstanding based on its Size and Cultural Significance.

The order from most to least monumentality thus obtained can be useful for defining management and conservation priorities, as well as for budget allocation within the context of a policy of support for the maintenance and preservation of monumental trees and of trees with characteristics of monumentality in the various cities of the country.

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Conflict of interests

The authors declare no conflict of interests.

Contribution by author

Nazly A. Mejorado Velasco: research design, information collection, drafting of the manuscript; José Luis Romo Lozano: research design, support in the description of the information, contribution to the methodology; Antonio Villanueva Morales: support in the drafting of the manuscript; Amparo M. Borja De la Rosa: support in the description of the information.

References

Alanís F., G. J. y A. R. Ledezma M. 2013. Sobre árboles monumentales o notables. Ciencia UANL 16: 20–25. https://go.aws/2OKW06C (14 de octubre de 2020).

Árboles Monumentales. 2013. Árboles Monumentales. https://www.monumentaltrees.com/es/ (25 de enero de 2020).

Asan, Ü. 2017. Mystical and holistic aspect of the monumental trees, and their importance for ecotourism. International Symposium on New Horizons in Forestry. 18-20 October 2017. Isparta, Turkey. pp. 50–58. https://bit.ly/2uu3wfz (10 de enero de 2020).

Asciuto, A., V. Borsellino, M. D'Acquisto, C. P. Di Franco, M. Di Gesaro and E. Schimmenti. 2015. Monumental trees and their existence value: Case study of an Italian natural park. Journal of Forest Science, 61(2): 56–61. Doi: 10.17221/86/2014-JFS.

Athawale, V. M. and S. Chakraborty. 2010. Facility location selection using PROMETHEE II method. *In:* Proceedings of the 2010 International Conference on Industrial Engineering and Operations Management. 9-10 January. Dhaka, Bangladesh. pp. 59-64.

https://www.researchgate.net/publication/228221619_Facility_Layout_Selection_Using_PROMETHEE_II_Method (18 de octubre de 2019).

Bottero, M., C. D'Alpaos and A. Oppio. 2018. Multicriteria Evaluation of Urban Regeneration Processes: An Application of PROMETHEE Method in Northern Italy. Advances in Operations Research, 1-12. Doi: 10.1155/2018/9276075.

Boyer, C. R. 2007. Revolución y paternalismo ecológico: Miguel Ángel de Quevedo y la política forestal en México, 1926-1940. México. https://www.redalyc.org/articulo.oa?id=600/60057103 (15 de noviembre de 2019).

Brankovic, J. M., M. Markovic and D. Nikolic. 2018. Comparative study of hydraulic structures alternatives using promethee II complete ranking method. Water Resources Management, 32(10), 3457-3471. Doi: 10.1007/s11269-018-2001-x.

Brans, J. P and Y. De Smet. 2016. Promethee methods. *In*: Greco, S., M. Ehrgott and J. R Figueria. (Eds.). Multiple Criteria Decision Analysis: State of the Art Surveys. Ed. Springer. New York, NY USA. 195 p. Doi: 10.1007/978-1-4939-3094-4_6.

Brans, J. P and P. Vincke 1985. Note-A- preference ranking organization method. Management Science, 31(6): 647–656. Doi: *10.1287/mnsc.31.6.647.*

Çağlar, Y. 2014. Thoughts on Monumental Trees management. Ankara, Turkey. https://bit.ly/2OJ6XG4 (6 de enero de 2019).

Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (Conabio). 2011. División política estatal 1:250000 (Versión 4, modificado de Conjunto de Datos vectoriales y toponimia de la carta topográfica). Serie III. Instituto Nacional de Estadística, Geografía e Informática (2003-2004). http://www.conabio.gob.mx/informacion/metadata/gis/dest_2010gw.xml?_httpcache=yes&_xsl=/db/metadata/xsl/fgdc_html.xsl&_indent=no (22 de agosto de 2019).

Cortés C., Y y N. León R. 2017. Valoración económica ambiental para los árboles patrimoniales de Bogotá. International Business and Economics Review 8: 504–33. https://bit.ly/2ULwAts (14 de noviembre de 2019).

Ehrle, E. B. 2003. The Champion Trees and Shrubs of Michigan. The Michigan Botanist 42(2): 3–46. https://bit.ly/2uu4hFr (15 de octubre de 2019).

Fadlina, L., S. Tomoria, A. Karim, A. P. Mesran and S. Utama. 2017. Best student selection using extended Promethee II Method. International Journal of Recent Trends in Engineering and Research 3:21-29. Doi:10.23883/IJRTER.2017.3382.SK4CV.

Gutiérrez Á., G. 2016. Árboles monumentales: un patrimonio natural no reconocido en Chile. BOSQUE 37(2): 445-449. Doi: 10.4067/S0717-92002016000300001.

Hernández, A. 2019. El ahuelito de los oaxaqueños y treinta y cuatro historias de ahuehuetes más. Elementum. Pachuca, Hgo., México. 112p.

Instituto Nacional de Ecología y Cambio Climático (INECC). 2007. Árboles notables. https://bit.ly/3buPkDz (12 de febrero de 2019).

Ishizaka, A. and P. Nemery. 2013. Multi-Criteria Decision Analysis: Methods and Software. Wiley editorial. Chichester West Sussex, United Kingdom. 296 p.

Lonsdale, D, 2015. Árboles veteranos: guía avanzada para su gestión. Lifelong Learning Programme. Londres, United Kingdom, 197 p. https://bit.ly/2UMZTfd (10 de septiembre de 2019).

Meza A., M. C. 2015. Los árboles de la Ciudad de México. Guardianes de su imagen y calidad ambiental. Bitácora Arquitectura 31: 96–103. Doi: 10.22201/fa.14058901p.2015.31.56652.

Palczewski, K. and W. Sałabun. 2019. Influence of various normalization methods in PROMETHEE II: an empirical study on the selection of the airport location. Procedia Computer Science, 159: 2051-2060. Doi: 10.1016/j.procs.2019.09.378.

Sidney, C. 2013. Register of significant trees. Sidney, Australia, 243 p. https://bit.ly/37c1az6 (14 de marzo de 2019).

Smart Picker. 2019. Smart Picker Pro. Version 4.3. Brussels, Belgium. n/p.

Vargas M., F. 1997. Compendio de árboles históricos y notables de México. Instituto Nacional de Ecología, Semarnap. México, DF., México. 52 p.

Verástegui, F. 2013. Árboles emblemáticos de Oaxaca. Patrimonio vivo de la humanidad. Gobierno Municipal de Oaxaca. Oaxaca, Oax., México. 72 p.

Veza, I., S. Celar and I. Peronja 2015. Competences-based comparison and ranking of industrial enterprises using PROMETHEE method. Procedia Engineering, 100: 445–449. Doi: 10.1016/j.proeng.2015.01.389.

Villanueva D., J., J. Cerano P., D. W. Stahle., V. Constante G., L. Vázquez S., J. Estrada Á y J. D. Benavides S. 2010. Árboles longevos de México. Revista Mexicana de Ciencias Forestales 1(2): 7–29. Doi: 10.29298/rmcf.v1i2.634.

Villota G., M. 2018. Estado actual de la legislación autonómica de los árboles singulares: del concepto a la protección. Cuadernos de la Sociedad Española de Ciencias Forestales 44(1): 61-76. Doi: 10.31167/csef.v0i44.17546.

Villota G., M. 2016. Los árboles en el paisaje. Propuesta de un modelo para su evaluación: El caso del territorio histórico de Álava. Cuadernos de la Sociedad Española de Ciencias Forestales 44:611-618. Doi: 10.31167/csef.v0i42.17513.

Wendpanga, Y., J. 2019. The ranking of districts in Ouagadougou by the risk of flood and runoff using PROMETHEE. European Journal of Pure Applied Mathematics 12(4):1731-1743. Doi: 10.29020/nybg.ejpam.v12i4.3562.

Yilmaz B. and M. Dağdeviren. 2011. A combined approach for equipment selection: F-PROMETHEE method and zero-one goal programming. Expert Systems with Applications 38: 11641–11650. Doi: 10.1016/j.eswa.2011.03.043.

Zapponi, L., G. Mazza, A. Farina, L. Fedrigoli, F. Mazzocchi, P. F. Roversi, G. S. Peverieri and F. Mason. 2017. The role of monumental trees for the preservation of saproxylic biodiversity: re-thinking their management in cultural landscapes. Nature Conservation 243: 231–243. Doi: 10.3897/natureconservation.19.12464.