Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)
Available online at www.inia.es/sjar

Spanish Journal of Agricultural Research 2008 6(3), 341-352
ISSN: 1695-971-X

A comparative analysis of methods for the valuation of urban trees in Santiago del Estero, Argentina

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Abstract

Trees are living elements interspersed throughout our cities, and are considered by economists to be «fixed assets». Though they form part of our cities they do not have a set price as normally understood and calculated within the framework of a perfectly competitive market. The main aim of this article was to compare the main methods developed in the USA (North American) and Europe (Finnish, Swiss, French and Capitalisation methods) for determining the monetary value of urban trees in the town of Santiago del Estero, northeastern Argentina. The values of eight specimens of the most abundant species in the city (*Brachychiton populneum, Citrus auriantum*, *Grevillea robusta, Jacaranda mimosifolia*, *Sapindus saponaria*, *Tabebuia impetiginosa, Thevetia peruviana*, and *Tipuana tipu*) were calculated using all five methods mentioned above and the mean values returned compared by ANOVA. The results suggest a methodology combining both capitalisation and parametric indices might be the most useful way of determining the value of city trees.

Additional key words: appraisal, capitalisation, evaluation, parametric indices.

Resumen

Análisis comparativo de métodos de valoración del arbolado urbano. Aplicación a Santiago del Estero (Argentina)

El árbol urbano es un elemento vivo, al que los economistas llaman «inmovilizado», inserto en las ciudades. Forma parte de ellas, pero no tiene un precio determinado, tal como es éste concebido y deducido en el ámbito de un mercado de concurrencia perfecta. El objetivo principal de este trabajo es comparar los métodos más utilizados en EEUU (norteamericano) y Europa (métodos Finés, Suizo, Francés y de Capitalización) para la valoración del arbolado urbano de la ciudad de Santiago del Estero, al norte de Argentina. Se han aplicado los cinco métodos para calcular el valor de las ocho especies más abundantes en la ciudad (*Brachychiton populneum, Citrus auriantum*, *Grevillea robusta, Jacaranda mimosifolia*, *Sapindus saponaria*, *Tabebuia impetiginosa, Thevetia peruviana*, y *Tipuana tipu*), y se han comparado mediante un test ANOVA. El análisis de los resultados obtenidos en las distintas valoraciones conduce a proponer la aplicación de un sistema mixto entre la capitalización y los índices paramétricos.

Palabras clave adicionales: capitalización, evaluación, índices paramétricos, tasación.

Introduction

Urban forestry is generally defined as the art, science and technology of managing trees and forest resources in and around urban community ecosystems for the physcological, sociological, economic, and aesthetic benefits trees provide society (Konijnendijk *et al.,* 2005).

The presence of trees, whether grouped together in green spaces or lining streets, is considered essential in improving the quality of life and well-being of city dwellers. The function of such trees is primarily orna-

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Received: 01-07-07; Accepted: 30-06-08.

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Abbreviations used: AEPJP (Asociación Española de Parques y Jardines Públicos), CTLA (Council of Tree and Landscape Appraisers), DGATU (Dirección General de Acción Territorial y Urbanismo), ISA (International Society of Arboriculture), SD (standard deviation), $a (Argentine pesos, 2003 value = 0.29 €).

mental — the product of their arrangement and appeal to the eye. There is no doubt, however, that they also have other important functions such as providing a setting for recreation (Gundersen *et al.,* 2006), contributing to the overall well-being of citizens (O'Brien, 2005), improving climate in cities, regulating air exchange, filtering polluting substances, reducing wind speeds, muffling noise, and reducing atmospheric carbon dioxide concentrations, etc. (Akbari *et al.,* 2001; Nowak and Crane, 2002; Nowak *et al.,* 2004*,* 2006). Although the greatest efforts to promote and preserve diversity have been focused on natural habitats, preserving biodiversity should also be an important goal in the urban environment. Urban foresters should therefore search for management practices that preserve and promote this (Alvey, 2006).

The relentless growth of urban areas due to the influx of people into cities has led to a major deficit in green areas and, by extension, in tree cover. The maintenance and conservation of these spaces and the planning and installation of new ones has become increasingly important for public authorities, and in some cases a cause for legitimate concern. Under such circumstances the valuation of trees (or at least an approximate knowledge of their worth) is required in order to place them on an equal footing with other elements of the urban landscape (Bradley, 1995).

The different methodologies for the valuation of urban trees have been classified into two large groups (Espluga González de la Peña, 1989):

— Multiplicative or parametric methods.These define and quantify one, two or more physical, explicative and objective variables and combine these with other, more subjective, difficult-to-measure variables (aesthetic appeal, location, historical significance, etc.) related to the presence of trees in cities. The work of Price (2003) is an example of the difficulties encountered in quantifying the aesthetic benefits of urban forestry. The final value is determined by the equation:

$$\text{Value} = f(x_1,x_2,x_3,x_4,\ldots,x_n)$$

where $x_1, x_2,\ldots,x_n$ are any of the variables mentioned.

— Economic or capitalisation methods.These are based on the use of different procedures for the valuation of investments. They distinguish between objective and subjective criteria, which in the previous group are combined. These methods make it possible to set a monetary value for a living element via the following equation:

$$\text{Value} = f(t)$$

where t is the age of the tree.

The following types of valuation method were reviewed before making a selection of five methods that were compared in the present work (from the oldest to the most up-to-date):

— North American capitalisation methods: Robinette (1983), Faubert and Canonne (1993).

— North American parametric methods: National Shade Tree Conference (1957), CTLA (1992, 2000), Chadwick and Neely (1975), Grey (1978), Neely (1984).

— European capitalisation methods: Bernardini (1958), Simpferdorfer (1979), Meyer (1982), Benassi (1983), Bovo and Peano (1989).

— European parametric methods: Helliwell (1967, 2000), Misseri (1973), Bridgeman *et al. (*1979), Wycherley (1979), Genin and Plantiveau (1982), Ferraris (1984), Bovo and Peano (1989).

— Spanish capitalisation methods: Caballer (1989, 1999), Norma Granada (AEPJP, 1990, 1999).

— Spanish parametric methods: López Arce (1975), DGATU (1982), Palomares (1986).

— Argentine parametric methods: Codina and Barón (2003), Mazzoni (2003).

— Mixed method: Norma Granada (AEPJP, 1999); Contato Carol (2004).

— Other parametric methods: Fabbri (1989), Salvador (1990), Moore (1991), McPherson (1992), Faubert and Canonne (1993), McPherson *et al.* (1994), Flook (1996), Burnley method (McGarry and Moore*,* 1988); McPherson and Simpson (1999a,b).

European countries, with Switzerland at the forefront, prefer to place a value on trees from the point of view of their architectural contribution, beauty and cultural and historical significance. They introduced the ideas of «ornamental value», «tree with historical significance» or «distinctive tree». These definitions have served to demonstrate to economists, technicians, politicians and urban managers that the trees in urban conglomerations are much more than fixed assets, and that their intrinsic value goes far beyond all their functional uses. Nevertheless, in their zeal to extol the ornamental value of trees, European methods are reluctant to award a value of zero to a tree even when it is in danger of falling and poses a risk to property and people, or when it is located in an inappropriate place, or when it no longer has any functional value. The European methods always increase the base value of a tree.

Capitalisation methods have been defined as «authentic» by economists. This type of analysis takes into account all the costs involved in tree management tasks and considers this as an investment which is capitalised over time. Economists do not agree, however, as to which interest rates are best suited to formulate this econometric valuation.

All the methods consider the location of a tree as an element that influences its value. The nearer a tree is to the city centre, the greater its value (in such areas the effects of urban stress on trees are greater, making them more costly to maintain). Districts with a greater historical or cultural value are usually found in the centre. Thus, in the methods reviewed, the value of a tree is directly linked to the value of the land.

Simpferdorfer (1979), Fabbri (1989) and Caballer (1989, 1999) indicate that when valuating trees within the private sector, the system of evaluation by means of capitalisation (adjusted to different interest rates according to the criteria adopted) is more widely accepted. Parametric or multiplicative methods are better suited for the valuation of trees within the public sector, owing to their simplicity, speed and efficiency.

All these methods have their positive features, however, and make valuable contributions regarding how to set a monetary value on a living element. Urban trees are considered by economists to be «fixed assets», interspersed throughout our cities, but which have no specific price in a perfectly competitive market. Therefore, city administrators risk becoming involved in legal claims with individuals or other entities sanctioned for damaging trees if the size of sanctions are calculated using parametric scales that are not clearly understood (because of their subjective nature) by the sanctioned party; there is therefore a danger that such sanctions may be seen as unjust. The method traditionally accepted in the Argentine Civil Code for quantifying punitive damages is the Capitalisation method, although parametric methods are better suited for evaluating trees in the public sector, as mentioned above. The aim of this work was to compare the most common methods for the valuation of urban trees growing in the town of Santiago del Estero, in northeastern Argentina, to determine the method most suitable.

Material and Methods

Material

Santiago del Estero is the capital city of the Province of Santiago del Estero in the northeast of the Republic of Argentina; it lies in the middle of the Gran Chaco plain on the right bank of the River Dulce. It has a semi-arid climate. The Gran Chaco forms the phytogeographic Chaquenian province (northern Argentina, northwestern Paraguay, southwestern Brazil and southeastern Bolivia). The city itself comprises 49 districts spread over 4,538 ha; its built-up area covers about 4,500 ha.The population of the city is 245,000. There are a total of 630 ha of green spaces, including parks, squares, avenues, flat roofs, access roads and other features (Contato and Antonio, 1998).

One specimen of the eight most abundant tree species (see photographs in Table 1) in the city of Santiago del Estero was included in the study:

Species 1: *Tabebuia impetiginosa* (Mart. ex DC.) Standl. Common name: *Pau d'arco* or trumpet tree. A native of Argentina from the Tucumán-Oranense forests, this species can reach imposing heights and is considered the most beautiful of all urban trees in Santiago del Estero. Although it grows well in the city it does not exceed heights of 12-15 m. When they have not been badly pruned and/or damaged in their early years, trumpet trees grow with tall straight trunks and have a characteristic broad umbrella-shaped canopy.

Species 2: *Tipuana Tipu* Benth. Common name: White Tipu tree or rosewood. In its native region (Gran Chaco) it can reach heights of over 30 m. In the city it does not exceed 20 m. When left unpruned the canopies have a rounded or spherical appearance. The foliage is dense and deciduous and falls just before Spring (between August and October).

Species 3: *Grevillea robusta* A. Cunn. Common name: grevillea or silky oak. Native to southeastern Australia. This is a tree with a very attractive appearance and can exceed heights of 15 m. Young trees have a pyramid-shaped canopy which then spreads in maturity. It has dark-green evergreen foliage.

Species 4: *Brachychiton populneum* (Schott. & Endl.) R. Br. Common name: whiteflower kurrajong. An ornamental tree from Australia that grows to heights of up to 8 m; it has a spherical canopy and an attractive glossy dark-green semi-evergreen foliage.

Species 5: *Sapindus saponaria* L. Common name: soapwood tree. A short tree that does not exceed heights of 10 m in its native region, the Gran Chaco Plain. The flowers are small and white. It has a heavy spherical canopy with evergreen foliage that provides good shade; it makes an excellent street tree. Its roots do not cause damage and the foliage tolerates pruning well.

Species 6: *Citrus auriantum* L. Common name: bitter orange tree. A tree from the forests of Central Asia. In the temperate regions of Argentina, with their limey, non-saline soils, it can reach heights of 10 m. It has a spherical canopy and the foliage is heavy and dense.

Species 7: *Thevetia peruviana* (Pers.) K. Schum. Common name: tevetia. This is a shrub from tropical American forests. It has evergreen foliage and a long flowering period; it is very ornamental. It is inclined to branch out from the base of the stem, so requires pruning.

Species 8: *Jacaranda mimosifolia* D. Don. Common name: jacaranda or tarco. This is a tree from central South America. These trees reach heights of up to 20 m, grow with tall straight trunks, and have a spherical and/or umbrella-shaped canopy. The flowers form attractive pale purple bunches.

Methods

Of the valuation methods reviewed, the five most commonly used at the present time were compared in terms of the economic values they placed on the above trees:

— The North American method (CTLA, 2000).This only considers the utilitarian aspect of trees-initially the value of their wood, but in recent years their value has also been estimated in terms of energy savings, air pollution and other environmental utilities. This method gave rise to the idea of a «base value» as an expression of the unit price of a section of trunk, and considers the maximum value of a tree to be the product of this base value multiplied by the area of the section of the trunk. Corrector indices (species, condition and location) maintain or reduce this value, but never increase it.

$$\text{Value} = [\text{trunk area (cm}^2) \times \text{basic price cm}^{-2}] \times \times \text{species} \times \text{condition} \times \text{location} \quad [1]$$

— The Swiss method (Ferraris, 1984) is a multiplicative procedure, and takes into consideration four basic indices: species (E), state of health and aesthetic value (B), location (U), and size (D). These variables are separated qualitatively to avoid errors of judgement. This method also evaluates damage to trees, including that which does not involve the total loss of the tree. The method makes use of the following formula:

$$\text{Value} = E \times B \times U \times D \quad [2]$$

— The Finnish method (Caballer, 1999).This is a multiplicative procedure. A base value for each genus and species is established for each square centimetre of a section of trunk taken 1 m above the ground. The value of any individual tree is then found by multiplying its cross sectional area at this height by this base value. This is then corrected using a location index (according to whether the tree is in the city or in the country; the value of a city tree is always increased by this step) and a discount parameter based on the specimen's state of health and conservation. The final value is therefore expressed as:

$$\text{Value} = S \times P \times L \times E \quad [3]$$

where S is the section of the trunk, P is a value established and tabulated per cm^2 of section (which varies according to species), L is a variable defining the location (open country 1.3, forest 1.8, city 2), and E represents the condition of the tree on a descending scale from 1 for completely healthy to 0.2 for a very ill and weakened specimen.

— The French method (Ferraris, 1984).This establishes an index related to the cultivation care (T) required for the maintenance of the specimen. Ferraris (1984) reviewed the Swiss methodology and adapted it to include T in the valuation expression in order to fix a monetary value for trees in private parks and gardens in France. This method attempts to define the most likely cost of replacement. The value is arrived at via the use of four indices: a species index (E), an index of health and aesthetic value (B), a location index (L), and a size index (D) (with values determined according to the ranges of the normal circumference). The expression used in the valuation of trees:

$$\text{Value} = E \times B \times L \times D \times T \quad [4]$$

— The capitalisation value used in the present work was obtained from Caballer (1999), as adapted by Contato Carol (2004) to the costs of Santiago del Estero:

$$\text{Value} = \text{initial cost} + \text{transport costs} + + \text{consumer planting costs} + \text{nursery costs} + + \text{possible supplementary costs} \quad [5]$$

where:

— Initial cost = (nursery price/α)$(1+i)^n$; i = interest rate; n = age at valuation; α = percentage of plants that settle in (expressed as annual planting performance).

— Transport costs = (5 \$$a$ /α)$(1+i)^n$; \$$a$ = Argentine pesos.

— Consumer planting costs = (15 \$a/α)$(1+i)^n$.

— Nursery costs = $\sum_{j=1}^{5} (\text{Nursery price})(1+i)^{n-j}$;

«j» = number of years the specimens are raised before being plantable.

— Possible supplementary costs = costs, in \$a, of supplementary tasks capitalised over the valuation time.

Tree variables

The following variables were recorded for one specimen of each of the above —mentioned species— selected randomly between those for which information was available (all of them in Centro district):

— Age. This information was obtained from the City Council archives.

— Normal circumference: at 1.30 m above the forest floor on the uphill side of the tree (measured in centimetres using a tape measure).

— Normal diameter: normal circumference/π.

— Normal section: $\pi \times$ normal diameter^2/4).

— Nursery price. Provided by the City Council nurseries (in \$a).

— Location. All the trees were selected in the Centro district —the district for which tree information was available.

— Condition: plant health was evaluated by the City Council's technical staff, taking into account-defoliation, discoloration, wounds on the trunk and large branches, the colour of the bark, etc.

Statistical analysis

The means of the value sets returned by each of the five methods were compared by ANOVA. This analysis decomposes the variance of tree value into the contributions made towards it by different factors. The contribution of each factor was calculated by least sums squares. Significance was set at $P < 0.05$. All calculations were made using Stargraphics v.5.1 software.

Results

Table 1 shows the characteristics of the eight specimens analysed, including:

— Age-ranging from 7 (specimen 3) to 116 years (specimen 2).

— Normal circumference-ranging from 32 (specimen 3) to 260 cm (specimen 2).

— Normal diameter-ranging from 10.19 to 82.76 cm.

— Normal section-ranging from 81.55 to 5,379.38 cm^2.

— Nursery price-ranging from \$a 5 to 8.

— Condition. Most trees were in very good condition and had a good appearance, except specimen 2.

Table 2 shows the results for the valuation of the selected trees by the five chosen methods.The Finnish, Swiss, French and North American methods make use of a base value (\$a cm^{-2}) obtained from the expression: nursery price/nursery specimen section. This base value was then multiplied by different indices (see equations [1-4]) to provide the definitive value of each tree. The value of specimen 1 ranged from \$a 328.61 (North American method) to \$a 896 (Swiss method); specimen 2 from \$a 575 (French method) to \$a 7,910.25 (Capitalisation method); specimen 3 from \$a 481.87 (North American method) to 1,064 (Swiss method); specimen 4 from \$a 52.19 (North American method) to \$a 466.86 (Capitalisation method); specimen 5 from \$a 386.43 (Capitalisation method) to \$a 2,560 (Swiss method); specimen 6 from \$a 302.37 (North American method) to \$a 1,152.11 (Capitalisation method); specimen 7 from \$a 355.68 (French method) to 711.36 (Swiss method), and specimen 8 from \$a 576 (French method) to \$a 2,037 (Finish method).

Studentised values for each tree (as determined by each method) were calculated to show by how many standard deviations each original value was separated from the sample mean of \$a 1,017.47 (see Fig. 1). The most extreme value was recorded for specimen 2 by the capitalisation method, at 5.35 standard deviations above the mean value for all methods together; it is therefore an outlier point in the sample.

Once the value of specimen 2 was removed, the values recorded by the other four methods were compared by ANOVA. This breaks down the variance of the final value of the tree into the contributions made by method and species (see Table 3).

The French and Capitalisation methods returned similar means and standard deviations for the values of the trees (see Table 4). The mean value for all the studied trees returned by the North American method was greater than that returned by the French and Capitalisation methods, although the standard deviation was similar for all of them. The Swiss and Finnish methods returned higher means and standard deviations than the other tests. Figure 2 shows the mean tree values and 95% confidence intervals returned by the five methods.

The differences between means returned by the following pairs of methods were greater than \$a 364:

Table 1. Characteristics of the trees analysed

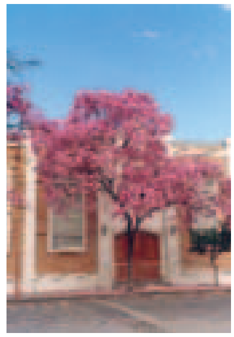
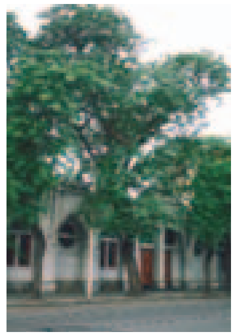
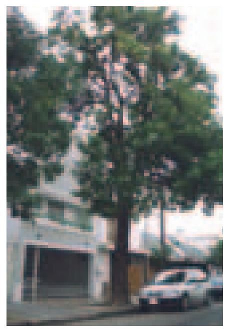
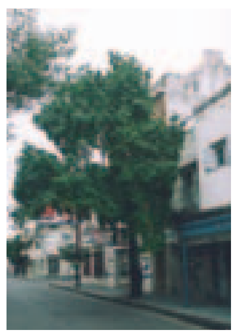
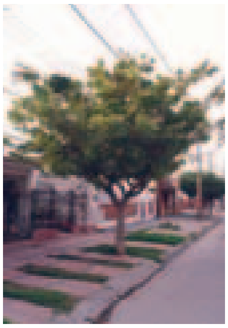
Specimen 1: *Tabebuia impetiginosa* (Mart. ex DC.) Standl		
Age	28 years	
Normal circumference	104 cm	
Normal diameter	33.12 cm	
Normal section	860.49 cm^2	
Nursery price (2003)	$a 7	
Location	At the edge of Leandro N. Alem. Street, Centro District	
Condition	Very good health	
Specimen 2: *Tipuana tipu* Benth.		
Age	116 years	
Normal circumference	260 cm	
Normal diameter	82.76 cm	
Normal section	5,379.38 cm^2	
Nursery price (2003)	$a 5	
Location	At the edge of a street in the Centro district	
Condition	Hollow, bad state of health	
Specimen 3: *Grevillea robusta* A. Cunn		
Age	7 years	
Normal circumference	32 cm	
Normal diameter	10.19 cm	
Normal section	81.55 cm^2	
Nursery price (2003)	$a 8	
Location	At the edge of a street in the Centro district	
Condition	Very good health and appearance	
Specimen 4: *Brachychiton populneum* Schott. & Endl.) R. Br.		
Age	27 years	
Normal circumference	96 cm	
Normal diameter	30.56 cm	
Normal section	733.5 cm^2	
Nursery price (2003)	$a 7	
Location	At the edge of a street in the Centro district	
Condition	Good health	

Table 1 (cont.). Characteristics of the trees analysed

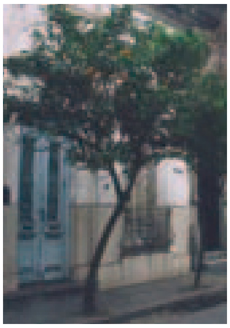
Specimen 5: *Sapindus saponaria* L.

Age	12 years
Normal circumference	92 cm
Normal diameter	29.28 cm
Normal section	673.32 cm^2
Nursery price (2003)	$a 6
Location	At the edge of a street in the Centro district
Condition	Very good health and appearance



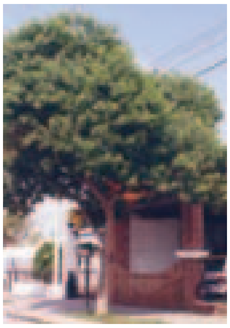
Specimen 6: *Citrus auriantum* L.

Age	60 years
Normal circumference	57 cm
Normal diameter	18.14 cm
Normal section	258.44 cm^2
Nursery price (2003)	$a 6
Location	At the edge of Mitre St. in the Centro district
Condition	Very good health and appearance



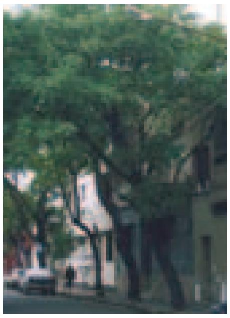
Specimen 7: *Thevetia peruviana* (Pers.) Schum.

Age	17 years
Normal circumference	64 cm
Normal diameter	10.37 cm
Normal section	325.88 cm^2
Nursery price (2003)	$a 6
Location	At the edge of a street in the Centro district
Condition	Very good health and appearance



Specimen 8: *Jacaranda mimosifolia* D. Don.

Age	45 years
Normal circumference	200 cm
Normal diameter	63.60 cm
Normal section	3,182.81 cm^2
Nursery price (2003)	$a 8
Location	At the edge of a street in the Centro district
Condition	Very good health and appearance



$a (Argentine pesos): 2003 value = 0.29 €.

Table 2. Monetary values of the eight trees calculated using the five different methods

North American method - Eq. [1]

Specimen	Circumference (cm)	Diameter (cm)	Section (cm²)	Nursery price ($a)	Base value ($a cm⁻²)	Size ($a)	Change after application of species index ($a)	Change after application of health index ($a)	Change after application of location index ($a)	Value ($a)
1	104	33.1	860.49	7	0.7	602.34	602.34	481.87	481.87	481.87
2	260	82.76	5,379.38	5	0.5	2,689.69	2,689.69	1,613.81	1,613.81	1,613.81
3	32	10.19	81.55	8	0.8	65.24	52.19	52.19	52.19	52.19
4	96	30.56	733.5	7	0.7	513.45	410.76	328.61	328.61	328.61
5	92	29.28	673.32	6	2	1,346.64	1,346.64	1,346.64	1,346.64	1,346.64
6	57	18.14	258.44	6	1.17	302.37	302.37	302.37	302.37	302.37
7	64	20.37	325.88	6	1.17	381.28	381.28	381.28	381.28	381.28
8	200	63.66	3,182.81	8	0.4	1,273.12	1,273.12	1,273.12	1,273.12	1,273.12

Swiss method - Eq. [2]

Specimen	Cicumference (cm)	Diameter (cm)	Section (cm²)	Nursery price ($a)	Base value ($a cm⁻²)	Age index	Health and conservation	Location	Value ($a)
1	104	33.1	860.49	7	0.7	19	8	10	1,064
2	260	82.76	5,379.38	5	0.5	46	6	10	1,380
3	32	10.19	81.55	8	0.8	2.8	10	10	224
4	96	30.56	733.5	7	0.7	16	8	10	896
5	92	29.28	673.32	6	2	16	8	10	2,560
6	57	18.14	258.44	6	1.17	7.6	8	10	711.36
7	64	20.37	325.88	6	1.17	7.6	8	10	711.36
8	200	63.66	3,182.81	8	0.4	36	8	10	1,152

Finnish method - Eq. [3]

Specimen	Cicumference (cm)	Diameter (cm)	Section (cm²)	Nursery price ($a)	Base value ($a cm⁻²)	Size ($a)	Location	Health and conservation	Value ($a)
1	104	33.1	860.49	7	0.7	602.34	2	0.8	963.75
2	260	82.76	5,379.38	5	0.5	2,689.69	2	0.5	2,689.69
3	32	10.19	81.55	8	0.8	65.24	2	1	130.48
4	96	30.56	733.5	7	0.7	513.45	2	0.8	821.52
5	92	29.28	673.32	6	2	1,346.64	2	0.8	2,154.62
6	57	18.14	258.44	6	1.17	302.37	2	0.8	483.08
7	64	20.37	325.88	6	1.17	381.28	2	0.8	610.05
8	200	63.66	3,182.81	8	0.4	1,273.12	2	0.8	2,037.00

French method - Eq. [4]

Specimen	Cicumference (cm)	Diameter (cm)	Section (cm²)	Nursery price ($a)	Base value ($a cm⁻²)	Age index	Location	Health and conservation	Value ($a)
1	104	33.1	860.49	7	0.7	9.5	10	8	532
2	260	82.76	5,379.38	5	0.5	23	10	5	575
3	32	10.19	81.55	8	0.8	1.4	10	10	112
4	96	30.56	733.5	7	0.7	8	10	8	448
5	92	29.28	673.32	6	2	8	10	8	1,280
6	57	18.14	258.44	6	1.17	3.8	10	8	355.68
7	64	20.37	325.88	6	1.17	3.8	10	8	355.68
8	200	63.66	3,182.81	8	0.4	18	10	8	576

Table 2 (cont.). Monetary values of the eight trees calculated using the five different methods

Capitalisation - Eq. [5]									
Specimen	**Interest rate**	**Age (years)**	**Nursery price (\$a)**	**Initial cost (\$a)**	**Transport cost (\$a)**	**Consumer planting costs (\$a)**	**Nursery costs (5 years) (\$a)**	**Possible supplementary costs (\$a)**	**Value (\$)**
1	0.04	28	7	74.97	53.55	160.64	86.40	99.26	474.82
2	0.04	116	5	407.74	407.74	1,223.21	1,946.74	3,924.83	7,910.25
3	0.04	7	7	150.39	94.00	281.99	18.36	0.00	544.73
4	0.04	27	8	74.75	53.40	160.19	83.07	95.45	466.86
5	0.04	12	6	80.05	66.75	200.13	39.54	0.00	386.43
6	0.04	60	6	105.20	87.66	262.99	259.79	436.47	1,152.11
7	0.04	17	6	68.75	57.29	171.87	48.10	64.48	410.50
8	0.04	45	8	103.84	64.90	194.71	192.34	193.36	749.14

\$a (Argentine pesos): 2003 value = 0.29 €.

North American – Finnish, North American – Swiss, Capitalisation – Finnish, Capitalisation – Swiss, Finnish – French, and French – Swiss. The differences between means returned by the following pairs of methods were less than \$a 364: for North American – Capitalisation, North American – French, Capitalisation – French, and Finnish – Swiss.

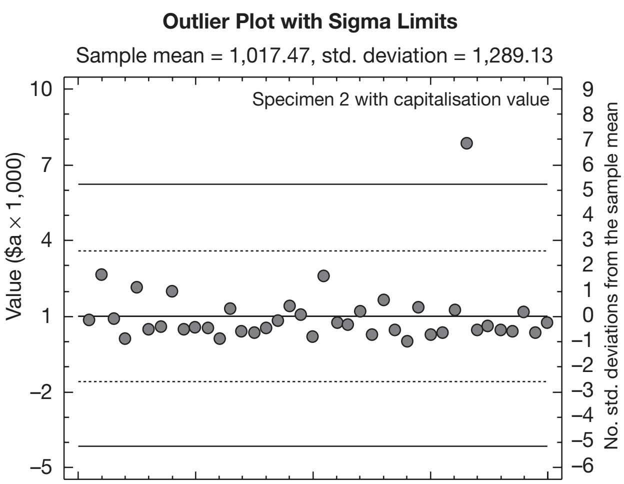


Figure 1. Outlier identificaton.

Discussion

Each valuation method was used with all eight specimens, except for the Capitalisation method (specimen 2 was rejected). The methods that give high priority to aesthetic and ornamental characteristics (the Swiss and Finnish methods) returned very high values (Fig. 2). The North American method, which relies on a base value per species expressed as price cm^{-2} of section of trunk, provided more moderate values (Fig. 2). Watson (2002), in a comparative study involving six specimens, obtained similar results. In the latter work, five different methods of tree appraisal (the North American, New Zealand, Great Britain and Norma Granada methods) were compared using six specimens of six different species in the grounds of The Morton Arboretum in Lisle (Illinois, USA).

Specimen 2 was awarded a lower value with the Swiss and French methods than with the other methods

Table 3. Analysis of variance of value

Source	Sum of squares	Df	Mean square	F-Ratio	P-value
Main effects:					
— A: method	2.76072×10^{-6}	4	690180	3.74	0.0151
— B: species	8.06714×10^{-6}	7	1.15245×10^{-6}	6.25	0.0002
Residual	4.97739×10^{-6}	27	184348		
Total (corrected)	1.60842×10^{-7}	38			

Table 4. Mean value for the examined trees returned by each method

Method	Number of trees examined	Mean value returned by the method	SD
North American	8	722.49	590.70
Capitalisation	7	597.80	272.34
Finnish	8	1,236.36	927.70
French	8	529.30	339.93
Swiss	8	1,087.34	689.08

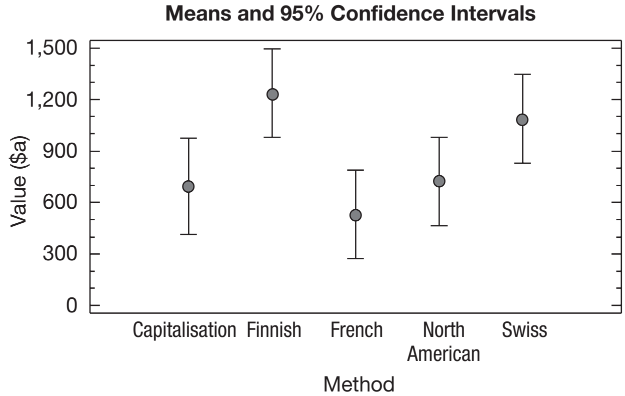


Figure 2. Mean tree values and 95% confidence intervals for the five methods.

since the former methodologies took into account the specimen's poor state of health (Table 1). The Capitalisation method overvalued this specimen (as shown by its Studentised value), due to its age and to the absence of a «state of health index» in the valuation expression.

The French and North American methods provided the most similar valuations. The French method takes into consideration the size of a tree only in terms of its age, while the North American model uses size as a dimension independent of age. So, if a specimen is very large (as is specimen 2) the American method would return higher values than the French model.

The Swiss and Finnish methods provided similar valuations. But when the health and conservation of the specimens are very different the results they return may differ.

The Capitalisation method provided the most different values in relation to the other methods. Although this is the most objective method, it does not employ indices to correct the monetary value of the tree. Thus, this method does not take into account the non-monetary functions of urban trees.

In conclusion, it would appear advisable to use a mixed system for determining the monetary value of trees in Santiago del Estero, based on the capitalisation of various expenses (the traditionally accepted method of quantifying punitive damages in the Argentine Civil Code) and their subsequent transformation into parametric indices. In other words, a parametric value system which is based on capitalisation might be better. Further work should test this hypothesis.

Acknowledgements

This work was performed within the joint doctoral programme of the Universidad Nacional de Santiago del Estero (Argentina) and the Universidad Politécnica de Madrid.

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