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Price premium for green open space and tree cover in the city of Buenos Aires

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PRICE PREMIUM FOR GREEN OPEN SPACE AND TREE COVER IN THE CITY OF BUENOS AIRES

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Abstract: Green areas provide aesthetic, recreational, social, and environmental benefits to surrounding communities. Local governments usually face many challenges while deciding on the protection of existing green space or the creation of new one. Understanding the direct economic impacts of green areas on neighboring properties can help with the economic and political decision-making. The aim of this study is to estimate individuals' valuations of green space in a highly densely populated city like Buenos Aires, Argentina. This paper applies spatial hedonic price models to obtain the value of urban green areas, urban trees, and tree cover. The results show a price premium for all green variables, and that not all trees are valued equally. Also, results suggest that more diversity increase the monetary value of a property. Results from this study could help inform the debate on the true opportunity costs of allowing construction over unused parcels of land in Buenos Aires.

Keywords: green open spaces, tree cover, urban economics, hedonic models, spatial econometrics, Buenos Aires.

JEL Classification: D12, Q51, Q57, R14, R21

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1. Introduction

In rapidly growing urban areas with increasing land prices, construction of housing and commercial property tends to become very profitable, and without proper land management green spaces can be crowded out. Urban green areas, such as parks, natural meadows or wetlands, provide critical ecosystem services, promote recreational activity and psychological well-being to urban residents, and also add aesthetic value (Wolch et al, 2014). These social and economic benefits include providing habitat to various animal species (insects, birds, small mammals); controlling soil erosion and limiting water runoff, which reduces the chance of experiencing flooding; improving air quality by intercepting particulate matter, ozone, and nitrogen dioxide; capturing carbon dioxide from the atmosphere; providing shading, which decreases energy use and mitigates the urban 'heat island effect'; diminishing noise pollution; and beautifying neighborhoods. Cities with more green amenities are also likely to have healthier citizens and therefore reduced demands on health services (Hartig and Fransson, 2009). Some of these benefits (habitat provision, carbon sequestration, and runoff reduction) are public goods, while others (esthetic qualities, air quality improvements, erosion reduction, and shading) are more like private goods so they are likely to be capitalized in the housing market (Saphores and Li, 2012).

A new paradigm is evolving regarding urban ecology, where the most salient thrust of current research is on urban sustainability (Wu, 2014). This imply focusing on urbanization patterns and their environmental impacts, as well as understanding the relationship between ecosystem services and human well-being. However, accounting for benefits derived from the provision of green amenities in residential areas have only recently been emphasized by policymakers. Local governments around the world are faced with many challenges while deciding where to protect or create green space, what type it should be, and how to do it economically, politically, and environmentally. Thus, it is important from a land policy perspective, to understand the trade-off in preferences for green areas and constructed space in urban settings.

In this context, identifying the willingness to pay for urban green areas is essential for cost-benefit analysis. Understanding the monetary contribution of these areas to their surrounding communities can help municipal planners estimate the additional property tax revenue they can expect from leaving areas undeveloped, which can offset the cost of acquisition. It can also be used to estimate the opportunity costs arising from the trade-off between open space uses and development density. To the best of our knowledge, there has been no prior attempt to estimate the people's valuation of green amenities in Buenos Aires, or elsewhere in Argentina.

This paper focuses in the City of Buenos Aires because it has one of the lowest ratios of green areas to total inhabitants among major Latin American cities. According to the 2010 Latin American Green City Index (EIU, 2010), Buenos Aires has only 6 square meters of green space per inhabitant, a figure that is well below the 9.5 square meters recommended by the World Health Organization (WHO). In contrast, Bogota has 107 square meters of green space per person, Curitiba 52, Mexico City 28, and Belo Horizonte 18. Buenos Aires' green areas are dwarfed in comparison with the 423 square meters per person in Guadalajara, the 750 square meter of Monterrey, or the 975 square meters per person in Brasilia.

On top of the problem of low availability of green spaces, Buenos Aires presents a challenge of accessibility since most of the green areas are concentrated in only few parts of the city. In this regard, WHO also recommends that all residents should live within a 15-minute walk to a green space. Moreover, urban tree cover seems to be also sparsely distributed in the City, but not necessarily correlated with the location of green areas, therefore justifying the analysis of both tree cover and green areas.

Recently, there has been an intense debate over unused parcels of land in Buenos Aires owned by the federal and the local government. While the majority of local residents aim to convert them into new public green areas, the municipal government has presented a plan to develop commercial and residential properties on those parcels. We expect to contribute to this debate by producing estimates of the value of green urban areas and tree cover in Buenos Aires.

Thus, the aim of the paper is to study whether or not there is a price premium in the housing market for green amenities by applying spatial hedonic models. In essence, the hedonic model views the price of individual houses as dependent on a bundle of housing characteristics. These characteristics are often related to the structure of the dwelling, the neighborhood attributes, the surrounding environmental quality, and property taxes. Thus, the spatial variation in housing attributes partially explains the spatial variability of housing prices. The hedonic approach allows uncovering the implicit price of each characteristic, thus providing information about people's willingness to pay for green variables. One of the major weaknesses of the existing literature on green areas is the use of ad hoc definitions of green space and tree cover, making very difficult to compare the findings from different papers. Therefore, another objective is to explore the sensibility of the results to different definitions of availability of green attributes.

Results suggest a positive relationship between green attributes and real estate values. For instance, a 1% increase in tree cover in the surroundings of a property increases its market price by around 0.005% for apartments and 0.015% for houses. Also, we show that not all trees are valuated in the same way. The Jacaranda, an iconic tree, is highly valued by people who live in apartments, for each 10 more jacarandas within 100 meters from the dwelling, its price increases by 2.9%. On average, a Jacaranda is valued 10.7 times more than an average tree. Furthermore, more tree diversity increase the value of a property. We also found that the proximity to public green spaces, such as squares and recreational parks, is valued positively and significantly by apartment's owners, while it seems to be not significant for house owners. Maybe because houses owners pay more attention to private green areas inside.

The remainder of this paper proceeds as follows: In the next section, we review the literature followed in section 3 by the methodology. Section 4 presents the data and section 5 the main results. We present the conclusions and a final discussion in the last section.

2. Literature review

There is an extensive literature about the value of green amenities in urban and rural areas, which we do not attempt to thoroughly review in this section. A complete review can be found in McConnell and Walls (2005), which describes applications of both revealed and stated preference methods for valuing various type of green spaces, such as parks, grassland, forested land, greenbelts, and wetlands. Studies tend to differ not only in the type of green spaces but also on the geographical scope of those benefits and the methodology to assess them, being hedonic price models applications the focus of this review.

Interestingly, the earliest work on valuing city parks was done by Milton Friedman (1962). He studied the problem of how to measure the positive externality on passersby derived from enjoying the aesthetic of the parks. His intention was to calculate the monetary value that could be charged to them.

The first empirical analysis was done by Kitchen and Hendon (1967). They look at the distance to a neighborhood park in Lubbock, Texas, and perform simple correlations of house-assessed values and distance. They found a significant positive correlation between them, since houses farther from the park seemed to be more valuable. Although this conclusion is based only on simple correlations that do not control for the many other factors affecting house prices, the result has been confirmed in some other studies (McConnell and Walls, 2005).

Weicher and Zerbst (1973) is usually pointed as being the first paper to apply regression analysis to control for possible variation in houses' structural characteristics (Mayor et al, 2009). The paper attempted to value the externality described by Friedman for several green areas in Columbus, Ohio. Among attributes of the property itself, their analysis included variables such as whether or not a house was close to and facing a park, whether it was close to and backing onto a park, and if a house was close to the park and facing an area with heavy recreational use. They found that the highest premium was paid if the houses faces a park, all else being equals. However, houses backing onto a park or close to recreational areas were sold for less. They attributed this findings to a loss of privacy and security. In the same line, Cheshire and Sheppard (1995) found that park and open space proximity generally added to property value, except where there were negative externalities such as traffic to a recreation facility, poor maintenance, or the presence of criminal or other "'undesirable'" populations in the park. More recent studies with a broader focus continue to pick up this negative effect on dwellings located next to busy urban and suburban parks (McConnell and Walls, 2005).

Since Weicher and Zerbst paper, dozens of other studies valuing of green attributes have been conducted in urban areas. For instance, Tyrvaeinen and Miettinen (2000) studied the value of urban forest amenities in the district of Salo in Finland, by comparing houses prices and specific amounts of amenities associated with dwelling units. They use distance to the nearest wooded recreational area, the direct distance to the nearest forested area, the relative amount of forested areas in the housing district, and the view from the dwelling window. Their results showed that a one kilometer increase in the distance to the nearest forested area leads to an average 5.9 percent decrease in the market price of the dwelling. Those houses with a view onto forests are on average 4.9 percent more expensive than dwellings with otherwise similar characteristics.

The study by Cho et al. (2008) uses data of real estate sales in Knoxville, Tennessee to assess how different features related to quantity and quality of open space are valued. They find that deciduous and mixed forests, larger forest blocks, and smoothly trimmed and man-made forest are more highly valued in urban core areas. Since the spatial variation in amenity values tend to differs across a metropolitan area, they argue for the need for site-specific land use management to fit the local characteristics.

In an interesting paper, Mansfield et al (2005) explore the idea of substitution in homeowners' preferences between trees on a parcel or in the neighborhood around that parcel, and living near large blocks of forest. Using data from the Research Triangle area in North Carolina, they find that greenness and forest cover are both positively correlated with the value of a parcel, and so is proximity to public and private forests. However, while adjacency to private forests seems to add value to houses, adjacency to public forests was not significant. Their interpretation of the results is that parcel greenness can substitute for proximity to private forest blocks and possibly complement proximity to public forests.

On a different geographical scale, possibly more related to the scope of our paper, the work by Voicu and Been (2008) analyze the impact of community gardens on neighborhood property values in New York City. They use a difference in difference specification of a hedonic regression model on residential properties, and find significant positive effects, especially in the poorest neighbourhoods. They also find that high quality gardens have the highest impact, indicating that the quality of the space is also an important attribute of green amenities.

Bolitzer and Netusil (2000) argue about the potential nonlinearity of proximity to green space on house prices due to the positive and negative externalities from living near an open space. Therefore, they use different distance thresholds from dwellings to green spaces in Portland, Oregon, to estimate the value of green amenities. They did not found evidence that the negative externalities associated with open space adjacency dominates the positive externalities, since houses one-half block of any type of open space showed the largest positive effect on their sale price.

Redevelopment of brownfields have also been subject of hedonic analysis of green amenities. This type of land is very important for real estate markets, particularly in those areas where green space is scarce. Green Leigh and Coffin (2005) analyze the impact of brownfields on property values in the cities of Atlanta and Cleveland. Particularly, they look at the effect of an announcement of a change of regulation on the price of houses close to brownfields.

Other papers like Des Rosiers et al. (2002), Geoghegan (2002), and Mayor, et al (2009) use the density of green areas within three circular buffers around the houses. Des Rosiers et al. (2002) look at the green space directly related to the house and the property's outdoor landscaping. They use data on houses sales in Quebec, Canada. This study has very detailed information on the percentage tree cover on the property and in the neighbourhood, as well as landscaping attributes (e.g. landscaped patio and curbs, rock plants etc.). They find that some of these landscape attributes added up to 4% to the price of a property through their visual impact. Anderson and Cordell (1988) provide even more detailed information on outdoor landscape attributes, and report that houses in Athens, Georgia, with on average five trees in the front yard, sold for 4% more than houses without, and that trees of medium to large sizes were valued more.

Geoghegan (2002) use the density of green areas within circular buffers around the houses. An original feature of this paper is the data allowed to separate open space into developable open space and permanent open space. The paper found that people valued permanent open space much more than green space that might be developed in the future. Mayor, et al (2009) estimates the value of green spaces and parks to homeowners in Dublin, Ireland. They combined data on house sales with available data on the location of green spaces. They found that distances to green areas is an important determinant of housing prices. Also, they found a difference in the values assigned to open access parks and green spaces. For every 10% increase in the share of green space and park area near a house, its average price increases by 7% and 9%, respectively.

Apart from the hedonic price models, other approaches have been used for estimating the value of urban land cover. A number of papers (see a meta-analysis by Brander & Koetse, 2011, for references) relied on the contingent valuation method (CVM), which asks people for their willingness to pay for changes in environmental quality under various hypothetical scenarios. However, the CVM relies on stated preferences that may not translate into actual behavior (Mayor et al, 2009).

One of the drawbacks of the existing literature on green amenities is that previous studies have seemingly used ad hoc definitions of green space and it's accessibility, and the definitions differ from one paper to another, making very difficult to compare the findings from different papers. Also, despite this extensive literature, we have noted that the empirical literature cited above is mostly focused in developed countries and that specific evidence for developing countries is lacking. In this paper we concentrate our effort in estimating the price premium for green areas and tree cover in one of the most densely populated Latin American cities.

3. Empirical Strategy

In order to provide useful information on people's preferences for green amenities in Buenos Aires we apply the hedonic demand theory to infer people's valuation of green areas and urban tree cover. Based on contributions to demand theory by Kevin Lancaster (1966), the hedonic model treats the price of real estate as dependent on a bundle of characteristics or attributes. These characteristics are often related to the structure of the dwelling (size, number of rooms, age of construction, architectural style, availability of parking space, etc.), neighborhood attributes (accessibility to public transportation and shopping districts, crime rate, etc.), and the surrounding environmental quality (air quality and availability and quality of green areas and urban tree cover). The hedonic model is built on the idea that the spatial variation in housing attributes partially explains the spatial variability of real estate prices. Therefore, the hedonic approach allows the estimation of *implicit* or *shadow* prices for each attribute, providing in the case of this study relevant information about people's willingness to pay for changes in the quantity of green areas and urban tree cover.

The full analysis of a hedonic price model can be divided into two stages: the estimation of the hedonic price equation and the estimation of the inverse demand function for the attributes of the property (see Rosen, 1974). The first stage analyzes the effect of the different housing attributes on real estate prices by estimating the hedonic price function. In such estimation it is possible to properly specify the econometric equation to estimate the marginal price of each attribute of the property. This is usually obtained as the partial derivative of the hedonic price function with respect to the variable of interest. The marginal price of that attribute is the market willingness to pay for a *marginal* change in that feature.

The second stage within the hedonic approach involves the estimation of the inverse demand function, which is the calculation of the marginal willingness to pay (MWTP) obtained in the previous step evaluated at the observed individual's characteristics. This latter step is useful to calculate the effect of non-marginal changes in attributes. The hedonic price function, as described in the first stage, isolates the effect of marginal changes in the analyzed attribute. With information at the individual level on the marginal willingness to pay, as well as their characteristics (e.g. income), it is possible, to some extent, to recover the demand for real estate, and also for the demand for attributes that do not have a market. However, the lack of data has limited the number of applications that estimate the final stage of the hedonic model. This work is no exception; thus the focus is kept only in the first stage of the hedonic approach.

Since the pioneer works of Rosen (1974) and Roback (1982), hedonic models have been widely applied to assess the implicit value of environmental amenities and the quality of life in urban centers. As mentioned before, although a vast literature exists on valuing urban green spaces, it is mostly focused on developed countries. This study is the first one to rigorously analyze the value of green urban amenities in the City of Buenos Aires or elsewhere in Argentina.

In real estate markets, it is a widely accepted assertion that *location matters*. In the estimation of hedonic models, it also matters the presence of *locational effects*. However, the explicit use of such information in modeling the hedonic price function has been recent in empirical studies. According to Anselin (1988) two problems arise when the data has a *locational component*: (i) the spatial dependence between observations, and (ii) the spatial heterogeneity in the relationships that are being specified.

In the housing market, spatial dependence can arise when real estate attributes tend to assume similar values in geographically nearby units (for instance, houses with larger backyards tend to cluster in certain areas). This spatial dependence is part of the error term, and therefore violates the classical assumption of Ordinary Least Squares (OLS) of no serial correlation between errors. If that correlation is ignored, the estimated parameters will be inefficient, the t and F statistics will be biased and the goodness of fit will be misleading (Anselin, 1992). In addition, spatial dependence may also stem from measurement problems in explanatory variables, omitted variables, and other forms of model misspecifications.

The spatial heterogeneity indicates the presence of systematic differences in the occurrence of a phenomenon in different geographical areas. The spatial heterogeneity can come from characteristics of demand, supply, institutional barriers, and racial discrimination, which can make the distribution of housing prices differ throughout the territory. The presence of spatial clusters violates the independence assumption and generates problems in the correct estimation of OLS regressions.

The presence of any of these spatial effects generates OLS estimates of shadow prices to be not only inefficient, but also biased and inconsistent, resulting in the need for alternative approaches. The detail of the consequences of ignoring the different types of locational effects has been widely discussed in the literature (see Anselin and Bera 1998; LeSage and Pace, 2009).

Our empirical strategy starts with the OLS estimation of a basic hedonic model that relates the price of a property with their attributes, environmental quality and socioeconomic characteristics of the neighborhood. Formally, the following model is estimated:

$$P= X\beta+S\gamma+E\tau+\mu,$$

In this specification $\boldsymbol{P}$ is a vector of real estate prices, $\boldsymbol{X}$ is a matrix of dwellings' characteristics, $\boldsymbol{S}$ is a matrix of neighborhood attributes and socioeconomic characteristics, and $\boldsymbol{E}$ is a matrix of attributes related to green amenities, μ is the error term, and β, γ and τ are the parameters to be estimated.

After obtaining the errors of the OLS estimation, Lagrange tests proposed by Anselin (2005) will be performed to detect the existence of spatial interactions. The proposed strategy to account for a potential locational or spatial effect is to estimate spatial hedonic models by maximum likelihood which considers not only the spatial dependence in the dependent variable, but also in the error term. These types of models are often referred as spatial-autoregressive models with spatial-autoregressive disturbances (SARAR). In short, the model can be written as $P= \varrho W^{I}P+X \beta+S\gamma+E \tau+\mu$, and $\mu=\lambda W^{II}\mu+\varepsilon$. In this specification $\boldsymbol{W}$ matrices are spatial weight matrices that capture the spatial relationships in the data.

The matrices, $\boldsymbol{W^{I}}$ and $\boldsymbol{W^{II}}$, are spatial weight matrices associated with a spatial autoregressive process in the dependent variable and in the disturbance term, respectively. The literature has documented various types of specifications that can be broadly classified as *contiguity* and *distance-based* matrices. We construct a spatial weight matrix using the distance decay matrix that assigns nearby real estate properties a higher weight than those that are further away $W_{ij} = d_{ij}^{-\alpha}$. In particular, we choose an alpha parameter equal to 2, which means that the weight is the inverse distance squared between any two observations[4].

The coefficient ϱ is the coefficient of the spatially lagged dependent variable whereas λ is the coefficient of the spatial autoregressive structure of the perturbation. The former shows the intensity of the spatial dependence and indicates how changes in the price of a given real estate property affects neighboring units. The latter coefficient measures the intensity of the spatial relationships in errors. It indicates that a random shock will affect not only the region where it was provoked, but will be transmitted to the entire system. Thus, the value of λ represents the intensity with which the shock is transmitted throughout space.

4. DATA

Buenos Aires was founded during the 16th century on mostly flat land on the shore of the Rio de La Plata. The city evolved as Argentina's main trading port, its financial and economic center and its political capital. During the last century the city expanded and absorbed neighboring localities and it currently represents the largest urban agglomeration in the country hosting a population of around 17 million people.

The studied area corresponds to the Autonomous City of Buenos Aires, which is the federal district within Buenos Aires Metropolitan Area, hosting the nation's capital. According to the 2010 population census, the federal district had almost 3 million people and more than one million households. The municipal government of the Autonomous City of Buenos Aires has the authority over land management and land regulations, particularly those related to green amenities. Green areas and street side tree cover within the federal district are well consolidated. Major parks and recreational areas have been established decades ago and had suffered relatively small changes since then. In contrast, population has been steadily rising increasing pressure on public land use.

[4] This type of weighting matrix is the most commonly used in spatial hedonic models applied to urban real estate markets. Alternatively, an $\alpha = 1$ implies that the weight decreases linearly with the distance between any two observations. Other weighting schemes assigns equal weights to every unit within a certain radius (often refereed as short-distance or radial-distance weights) and zero otherwise, but this might be problematic given the discontinuity implied by the definition. Other common alternative is to use the n-nearest neighbors, often treating equally each neighbor.

4.1. REAL ESTATE

In order to estimate the willingness to pay for green areas, trees and tree cover in the Autonomous City of Buenos Aires, we use more than five thousand properties listed for sale during 2009, distributed in 47 neighborhoods within the city. The data comes from the City of Buenos Aires Real Estate Database, an official dataset usually used to assess property taxes.

We should clarify that it was not possible to access data on real estate transactions and for this reason we have to rely on asking prices alone. Although formal housing markets are very well developed in Buenos Aires, transaction prices are almost always under-registered in order to avoid paying the corresponding taxes.[5] Therefore little is gained by abjuring the convenience of declared transaction values in the case of housing markets in Argentina.[6] Asking prices, although potentially different from the equilibrium values, are established mostly by experienced appraisers, which leads us to assume that they are not very different from their equilibrium values. Moreover, the relatively high market activity during the analyzed period (Argentina's GDP grew around 9% per year between 2004 and 2010) suggests that sellers very often sold properties for the asking price, implying that prices must have been close to the actual transaction values[7].

It is important to notice that in Argentina's real estate market frequently uses the US dollar as the currency of reference. This has become a necessity partly due to the country's history of monetary instability, which has gravely worsened since the hyperinflation of 1989-1990. In November 2011 began a series of restrictions on access to foreign exchange market, which hampered the free access to foreign currency. Such restrictions introduced distortions in the foreign exchange market, generating an informal currency market and creating several alternative values of the currency hindering the reference prices in the housing market. After such restrictions, a sharp decline occurred in the real estate sales. Since the introduction of such restrictions and according to the Association of Notaries of the Buenos Aires city registered sales during 2014 represents only 53% of the those of 2011, descending from 62 thousand to 33 thousand transactions in 2014. For this reason, we believe there are no reliable data on the real estate market activity after 2011[8].

The database contains standard dwellings' characteristics used to estimate hedonic price equations such as lot size, living space, number of rooms and bathrooms, parking availability, and age of the structure. To complement the real estate dataset we construct a series of neighborhood attributes for each

[5] Housing values for those properties bought with a mortgage are usually registered with the real transaction value because there is a financial institution involved. However, such transactions are rare in Argentinean housing markets. According to the Chilean Association of Banks, while housing loans in 2012 represented almost 18 percent of gross domestic product in Chile, and 6.8 percent in Brazil, it only reached 1.5 percent in Argentina.

[6] Of course, (unobserved) under-registration would not be an issue for the empirical exercise if the practice was uniformly applied throughout the market, e.g. if the transaction price of every house was under-reported, for instance by 10 percent. However, there is no evidence that such under-reporting is uniformly done across the market.

[7] Argentinean housing markets are not characterized by significant price negotiations between buyers and sellers. In general, real estate properties are sold for their asking price, and in the case that the house is not sold short after being listed sellers usually prefer not to decrease the price but keep the house in the market for a longer period. Even in more sophisticated housing markets, like in the United States, where buyers and sellers do engage in more negotiations, a significant proportion of houses are actually sold at their list price. For instance, Case and Shiller (2003) report that 48.4% of houses in four major US cities were sold for their asking price.

[8] In December 2015 the new government remove those restrictions on the access to foreign exchange market.

observation, such as access to public transportation (subway and train stations), public hospitals and health clinics, soccer stadiums, cultural facilities, crime rate, and other relevant features affecting real estate prices. The spatial distribution of houses and apartments are shown in Figure 1.

The real estate database shows that houses in the city of Buenos Aires have a higher sale price and are larger than apartments. An average house costs about 310,000 US dollars and had, on average, 225 square meters. Apartments cost, on average, 114,000 US dollars and have almost 80 square meters. The relatively modern origin of Buenos Aires explains the large number of avenues, on average a house is located less than two blocks from an avenue and 9.4 kilometers from downtown. As expected, apartments are closer to avenues, downtown (defined as the National Congress) and public transportation. Schools are evenly distributed across the city, so there is not much relative variability in this indicator. On the other hand, the subway network has low coverage for a city of this size and presents greater variability in distance to a subway or railway station (see Table 1).

We also include some neighborhood characteristics at census radius level, like average hourly wage, unemployment rate, share of homeowners, access to waste collection, and people without health coverage. This information came from the Argentinean National Census of Population, Homes and Household[9].

4.2. GREEN AMENITIES

In order to analyze green areas and tree characteristics we tried to build meaningful variables that capture the availability of green amenities in close proximity to each observation. Some are distance-based and others will take into account the density of a specific attribute in the neighborhood of a property. We have three types of green variables. First, the distance to the nearest private and public space. Second, tree cover average in several buffers and finally the variables related with the number and species of trees near each property.

For that we use spatial data on private and public green surface areas and a Census of trees with georeferenced information on each tree in the City, both provided by Ministry of Modernization, Innovation and Technology. Also we work with satellite information on tree cover for 2010 from the Global Land Cover Facility (GLCF) on 30 meters by 30 meters cells.

The data shows that there are no differences between apartments and houses in the distance to the nearest private or public spaces, 455 meters and 250 meters, respectively.

With the intention of measuring the average tree cover around properties we build several distance buffers (100, 250, 500, 750, and 1000 meters). In apartments, the average tree cover is almost 0.85% for all the buffers, which means that around an apartment the 0.85% of the buffer area is covered by tree canopy. In houses, it decrees from 0.59% to 0.57%, 0.54%, 0.49% and 0.46% for 100, 250, 500, 750, and 1000 meters, respectively. The spatial distribution of green areas is not perfectly correlated with tree cover as shown in Figure 2.

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[9] The average hourly wage is a weighted average of the hourly wage by educational level, gender and age from the Permanent Household Survey of 2010 weighted by the participation of each group of educational level, gender and age of each census radius.

The census of trees shows that there are more than 424 thousand trees in the City. Those trees belong to 180 different species, where the three most frequent species is Fraxinus with 37.22%, 8.65% of Platanus and 6.5% of Ficus. When we analyses the tree data, we found significant differences between houses and apartments. The number of trees that are around a house in Buenos Aires is really high. On average, there are 175 trees in a buffer of 100 mts, that amount increase to 898 in 250 mts, 4,221 in 500 mts and 15,696 in 1 km. Near an apartment, the numbers of trees are lower, 122, 667, 3,173, 7,108 and 12,602 in a buffer of 100 mts, 250 mts, 500 mts and 1 km, respectively. The diversity of species in BA is also high, on average we have almost 15 different species around 100 meters of a house and more than 10 near the same distance of an apartment. The amount of different species increases as we increase the buffer.

Although there are a lot of trees near a property, not all the trees are the same. One iconic tree of Buenos Aires is the Jacaranda, which is a sub-tropical tree native to south-central South America that has been widely planted elsewhere because of its beautiful and long-lasting blue flowers. At a 100 meters distance of a house there are, on average, 3.6 jacarandas but it ranges from 0 to 55, while, around apartments are almost 2 more jacarandas, and it ranges from 0 to 41 in 100 meters.

Another relevant feature that we extract from census tree data is the ratio of tree that lost their leaves during the year, those trees are called deciduous. Around 100 meters of an average house there are 6.5 trees that change their leave for one that it does not. That number rise to almost 8 for apartments and the ratio is stabilized around 5 in bigger buffers.

We also construct an index to measure species biodiversity, the Shannon index, which is used in ecology. The advantage of such index is that it is not necessary to identify the species present; it suffices to be able to distinguish one from another to perform the counting of individuals of each of them and the total count. This index is expressed with a positive number and has no upper limit. In most natural ecosystems varies between 0.5 and 5, although its normal value in Jungles and forests is between 2 and 3; Values below 2 are considered low in diversity and higher than 3 are high in diversity of species. The ecosystems with the highest values are tropical forests and coral reefs, and the smaller the desert areas.

The formula of the Shannon's diversity index is as follows:

$H = -\sum_{i=1}^{S} P_i ln P_i$, where S is the total number of species in the community (richness), pi is the proportion of S made up of the ith species.

We have calculated the index for several buffers, for houses presents higher values than for apartments, 1.25 vs. 1.07 although that difference decreases as we expand the buffers.

5. RESULTS

The results of our analysis on how green amenities affects property prices are presented in this section. We found interesting results related with tree cover and some tree variables, although a different relationship between houses and apartments was found. Apartments seems to valuate more some tree related variables than houses, maybe because houses have private green areas inside.

We estimate 4 different models[10], in the first one we include only one green variable by buffer, and in the second one we used tree cover and the number of jacarandas. The third model add the number of trees and the deciduous ratio. The fourth model adds the Shannon diversity index. The trees variables relate coefficients are presented in the Table 2 and 3. The first one present the OLS estimations while in the second Table the spatial hedonic model results[11].

5.1. Apartments.

Analyzing apartments, we found a positive relationship between tree cover and the price in the smaller buffer. A 1% more of tree cover in the surroundings (100/250 meters) increase the price between 0.005% and 0.012%. For higher buffers, the effect is not significant (Column 4 of Table 3).

Jacarandas are highly valuated for the people who lives in apartments, for each 10 more jacarandas around 100 meters of the living area, the price increase by 2.89% (Column 4 of Table 3) and this number is reduced to 7.7%, 5.3%, 3.1% and 1.8% as we consider higher buffers (250, 500, 750 and 1km).

The number of trees also has a positive relationship with the price, 10 more trees implies a price increase of 0.27% (Column 4 of Table 3) and that number is reduced as we consider higher buffers (250, 500, 750 and 1km). Something similar happened with the diversity index. More trees species and more diversity increase the value of a property.

This result indicates that not all trees are valuated in the same way, a Jacarandas add 0,289% more to a property value while and an average tree add only 0.027%. Therefore, a jacaranda is value 10.7 times more than an average tree.

The proximity to public green spaces, such as squares and recreational parks, is valued positively and significantly by apartment's owners. An increase in the distance by 1% reduce the house value in 0.01%.

The structural and neighborhood variables (no present in the paper for reasons of space, but available upon request) has the expected results. We found a significant and positive spatial autocorrelation in the prices of Buenos Aires. An apartment in a particular neighborhood tends to be influenced slightly by the prices of neighboring properties.

As one should expect, there is a positive and significant effect of the surface. The number of rooms is also significant. The negative sign for age and the positive sign for their squared suggest that newer apartments have higher prices. The price is positively influenced by the number of bathrooms. The results show that apartments are valued more when they are closer to the center and avenues. Analyzing the neighborhood characteristics, we found that only the employment rate and the average hourly wage is relevant to determine the price of the apartments of Buenos Aires.

[10] We include the property and neighborhood characteristics (including: house size, land area, bedrooms, bathrooms, age, stories, garage, distance to avenue, school, highway, CBD, subway station and train station. Also, average hourly wage, unemployment rate, share of homeowners, access to waste collection, and people without health coverage in the census radius and dummies by each 47 neighborhoods).

[11] The results of the 120 regression are available upon request

5.2. Houses.

In the case of houses, when we consider the tree cover variables we found that all are significant and positive. A 1% more of tree cover in the 100 meters surrounding of a house increase the price a 0.015% on average (column 4 of Table 3). There is a positive relationship between tree cover and the price of the house for all the buffers, the coefficients growth as it does the buffer. A more detailed analysis is necessary in this aspect.

The variables related with the number of Jacarandas, trees and species are not significant. However, the diversity index is significant buffers higher than 500 meters. The proximity to public green spaces seems to be not significant for house owners. Maybe because houses owners has green areas inside.

The household characteristics and the neighborhood variables appear reasonable and generally conform to our expectations. We found a significant and positive spatial autocorrelation in the prices of Buenos Aires. There is a positive and significant effect of the surface. The number of bedrooms is not significant. In addition, the negative sign of age and the positive sign for antiquity squared suggest that the newer houses are sold at relatively higher prices. With respect to bathrooms, houses assign a greater value to additional bathrooms. Something similar happens with the parking place and the number of plants. The distance variables are not significant and the only socioeconomic characteristics that have influence on the price is the average salary for the area which is positive and significant.

6. Conclusions

Urban green spaces, such as parks and forests, provides aesthetic, recreational, social and environmental benefits to surrounding communities. In rapidly growing urban areas with increasing land prices, construction of housing and commercial property tends to become very profitable and green spaces can be crowded out.

Understanding how the value of land cover is capitalized in the real estate market is important not only to real estate developers who could profit from building more desirable residential communities, but also to planners and local officials, so they can foster the adequate provision of the local public goods provided by urban green spaces by designing better zoning and land-use regulations (Saphores and Li, 2012).

In this paper, we showed the effect of green amenities on real estate prices using spatial hedonic models for the Autonomous City of Buenos Aires, Argentina. Our research not only considers modeling access to green amenities by measures based on distance, but also incorporates information about tree species and tree cover in explaining property values. We found a negative relationship between distances to green areas and prices, and a positive one with respect to tree cover and tree density. Also, our study suggests that Jacarandas, an emblematic species, are highly valued in real estate markets.

The results are interesting in respect to tree variables, since we found a different relationship for houses and apartments. Apartment owners seem to value more tree cover related variables than house owners. It is possible that people who live in apartment buildings pose a higher value on trees cover variables because houses have private green areas inside.

A couple of possible extension to this work will be added in the near future. In particular, it would be interesting to construct meaningful measures of the quality of green space, perhaps combining site data with tree cover, the type of recreational use, and the main characteristics of the site using remote sensing data. Also, it would be interesting to explore the possibility of endogeneity between real estate prices and green attributes (see Walsh, 2007, for a discussion).

The result of this project should not be generalized to other cities because those residents are likely to have different tastes for urban trees or green amenities. Finally, we believe that this study has important implications when deciding on infrastructure investments. The estimated willingness to pay should be confronted with the expected costs of alternative projects in order to prioritize where to protect or create green space and what type should it be.

Annex of tables and figures

Table 1. Descriptive Statistics

Variables	Houses Mean	Houses Standard deviation	Apartments Mean	Apartments Standard deviation	Difference
Price (USAD)	310,629	[305244]	114,298	[2063]	303181***
House size (square meters)	196.80	[1.67]	70.63	[1.45]	1.02***
Land area (m2)	211.12	[1.67]			
Number of bedrooms	3.44	[1.35]	1.68	[1.03]	1.76***
House age (year)	32.66	[20.64]	12.95	[18.7]	19.71***
Number of bathrooms	2.48	[1.31]	0.55	[0.87]	1.94***
Number of Stories	1.93	[0.74]			
Garage	0.75	[0.43]			
Distance to avenue (km)	0.16	[0.14]	0.12	[0.11]	0.04***
Distance to school (km)	0.19	[0.1]	0.15	[0.09]	0.04***
Distance to highway (km)	1.44	[1.1]	1.78	[0.96]	-0.34***
Distance to CBD (km)	9.36	[3.01]	6.21	[3.41]	3.15***
Distance to subway station (km)	2.48	[1.71]	1.17	[1.23]	1.3***
Distance to train station (km)	1.06	[0.56]	0.96	[0.5]	0.1***
Average hourly wage	510	[27.28]	530	[30.47]	-19.11***
Unemployment rate	20.6	[5.35]	17.0	[4.94]	3.59***
Share of homeowners	72.7	[10.18]	67.5	[11.02]	5.26***
Access to waste collection	99.4	[4.5]	99.4	[5.03]	-0.01
People without health coverage	26.7	[10.7]	22.0	[10.09]	4.66***
Nearest private space (mts)	456	[265.46]	438	[264.44]	17.61**
Nearest public space (mts)	249	[171.7]	249	[161.12]	0.24
Tree cover average in 100 mts	45.81	[1.1]	84.09	[1.39]	-0.38***
Tree cover average in 250 mts	48.94	[0.82]	83.88	[1.04]	-0.35***
Tree cover average in 500 mts	53.78	[0.64]	84.82	[0.76]	-0.31***
Tree cover average in 750 mts	57.03	[0.55]	85.10	[0.65]	-0.28***
Tree cover average in 1 km	59.27	[0.5]	84.31	[0.57]	-0.25***
Number of Jacarandas in 100 mts	3.67	[4.15]	5.51	[5.14]	-1.84***
Number of Jacarandas in 250 mts	18.00	[15.54]	27.38	[19.63]	-9.38***
Number of Jacarandas in 500 mts	67.03	[38.52]	102.31	[56.41]	-35.28***
Number of Jacarandas in 750 mts	144.49	[64.99]	222.96	[110.67]	-78.47***
Number of Jacarandas in 1 km	248.15	[93.48]	389.84	[180.94]	-141.69***
Number of Jacarandas in 1.25 km	377.05	[128.83]	596.91	[260.43]	-219.86***
Number of Jacarandas in 1.5 km	529.65	[170.53]	842.58	[345.62]	-312.93***
Number of trees in 100 mts	175	[60.9]	122	[56.64]	53.19***
Number of trees in 250 mts	898	[262.34]	667	[236.9]	230.82***
Number of trees in 500 mts	4,221	[907.42]	3,173	[1126.74]	1049***
Number of trees in 750 mts	9,125	[1754.98]	7,108	[2394.85]	2017***
Number of trees in 1 km	15,696	[2859.06]	12,602	[4121.62]	3095***
Number of trees in 1.25 km	23,842	[4289.31]	19,539	[6266.6]	4304***
Number of trees in 1.5 km	33,534	[6115.08]	27,882	[8804.22]	5652***
Number of tree species in 100 mts	14.9	[5.23]	10.4	[4.9]	4.47***
Number of tree species in 250 mts	34.6	[8.48]	28.3	[9.29]	6.25***
Number of tree species in 500 mts	58.1	[9.8]	51.9	[11.38]	6.27***
Number of tree species in 750 mts	73.3	[9.76]	68.1	[11.18]	5.24***
Number of tree species in 1 km	84.7	[9.48]	80.2	[10.92]	4.56***
Number of tree species in 1.25 km	93.5	[9.57]	89.9	[10.82]	3.59***
Number of tree species in 1.5 km	100.9	[9.58]	98.3	[10.95]	2.64***
Deciduous trees ratio 100 mts	0.07	[6.75]	0.08	[9.9]	-1.26***
Deciduous trees ratio 250 mts	0.05	[3.39]	0.06	[4.47]	-0.44***
Deciduous trees ratio 500 mts	0.05	[2.02]	0.05	[2.56]	-0.19***
Deciduous trees ratio 750 mts	0.05	[1.76]	0.05	[2.15]	-0.14**
Deciduous trees ratio 1 km	0.05	[1.66]	0.05	[1.94]	-0.08
Deciduous trees ratio 1.25 km	0.05	[1.55]	0.05	[1.77]	-0.02
Deciduous trees ratio 1.5 km	0.05	[1.46]	0.05	[1.62]	0.03
Shannon index in 100 mts	1.25	[0.23]	1.07	[0.28]	0.18***
Shannon index in 250 mts	1.33	[0.18]	1.28	[0.28]	0.05***
Shannon index in 500 mts	1.54	[0.13]	1.50	[0.21]	0.04***
Shannon index in 750 mts	1.57	[0.12]	1.55	[0.2]	0.01***
Shannon index in 1 km	1.59	[0.11]	1.59	[0.19]	0
Shannon index in 1.25 km	1.60	[0.1]	1.61	[0.18]	-0.02***
Shannon index in 1.5 km	1.61	[0.1]	1.63	[0.18]	-0.03***

*** p<0.01, ** p<0.05, * p<0.1

Table 2: OLS Regression results. Dependent variable logarithm of property value.

Variables	Houses				Apartments			
	Model				Model			
	1	2	3	4	1	2	3	4
100 meters buffer								
Tree cover (%)	0.015*	0.016**	0.016*	0.015*	0.006**	0.006*	0.006*	0.006**
# hundreds of Jacarandas	0.298	0.315	0.321	0.328	0.356***	0.353***	0.327***	0.335***
# hundreds of trees	0.006		-0.000	0.002	0.020***		0.014*	0.030***
Ratio of deciduous trees	0.001		0.001	0.001	0.000		0.000	0.000
# of Species	0.004			0.029	0.170			-0.672***
Shannon index	-0.014			-0.022	0.059***			0.139***
250 meters buffer								
Tree cover (%)	0.022*	0.023**	0.021*	0.021*	0.010***	0.011***	0.013***	0.014***
# hundreds of Jacarandas	0.078	0.085	0.096	0.095	0.107***	0.110***	0.099***	0.092***
# hundreds of trees	-0.001		-0.000	0.000	0.007***		0.007***	0.012***
Ratio of deciduous trees	0.007**		0.007**	0.007**	-0.002**		-0.003***	-0.003**
# of Species	-0.069			-0.056	0.133**			-0.229**
Shannon index	-0.036			0.022	0.040**			0.069**
500 meters buffer								
Tree cover (%)	0.039**	0.043**	0.036**	0.036**	0.006	0.008	0.014**	0.015**
# hundreds of Jacarandas	0.033	0.041	0.055	0.034	0.069***	0.069***	0.067***	0.063***
# hundreds of trees	-0.001		-0.002	-0.001	0.001**		0.002***	0.002**
Ratio of deciduous trees	0.011*		0.008	0.014*	-0.004**		-0.009***	-0.007***
# of Species	-0.078			-0.250	0.250***			0.032
Shannon index	0.131			0.356***	0.079***			0.030
750 meters buffer								
Tree cover (%)	0.063***	0.070***	0.058**	0.056**	-0.002	0.003	0.016*	0.017*
# hundreds of Jacarandas	0.018	0.026	0.037	0.022	0.043***	0.043***	0.041***	0.036***
# hundreds of trees	-0.001		-0.001	0.000	0.000**		0.001***	0.001***
Ratio of deciduous trees	0.017*		0.010	0.024**	-0.005**		-0.013***	-0.008**
# of Species	-0.152			-0.528***	0.320***			0.026
Shannon index	0.180			0.559***	0.098***			0.085
1km buffer								
Tree cover (%)	0.068**	0.079***	0.073**	0.062**	-0.008	-0.001	0.015	0.015
# hundreds of Jacarandas	0.019	0.026	0.033*	0.022	0.029***	0.029***	0.028***	0.023***
# hundreds of trees	-0.000		-0.001	-0.000	0.000*		0.001***	0.001***
Ratio of deciduous trees	0.007		-0.001	0.018	-0.006**		-0.015***	-0.009**
# of Species	-0.022			-0.306	0.344***			0.031
Shannon index	0.327**			0.557***	0.100***			0.110

* significant at 10%; ** significant at 5%; *** significant at 1%

Model 1: Includes only one tree cover variables at a time

Model 2: Use tree cover and the number of jacarandas

Model 3: Includes tree cover, number of jacarandas and deciduous ratio.

Model 4: Model 3 plus the Shannon index.

Table 3: SARAR Regression results. Dependent variable logarithm of property value.

Variables	Houses				Apartments			
	Model				Model			
	1	2	3	4	1	2	3	4
	100 meters buffer				100 meters buffer			
Tree cover (%)	0.015**	0.016**	0.016**	0.015**	0.005	0.004	0.004	0.005*
# hundreds of Jacarandas	0.328	0.345	0.331	0.343	0.310***	0.308***	0.281***	0.289***
# hundreds of trees	0.012		0.005	0.010	0.019***		0.014*	0.027***
Ratio of deciduous trees	0.001		0.001	0.000	0.001		0.000	0.000
# of Species	0.033			-0.004	0.162			-0.595***
Shannon index	-0.012			-0.029	0.053***			0.125***
	250 meters buffer				250 meters buffer			
Tree cover (%)	0.022**	0.023**	0.021**	0.021**	0.009**	0.009**	0.011***	0.012***
# hundreds of Jacarandas	0.072	0.078	0.082	0.083	0.092***	0.094***	0.084***	0.077***
# hundreds of trees	0.001		0.001	0.002	0.006***		0.007***	0.011***
Ratio of deciduous trees	0.006**		0.006**	0.006**	-0.002**		-0.003***	-0.002*
# of Species	-0.052			-0.064	0.140**			-0.186*
Shannon index	-0.034			0.006	0.037**			0.063**
	500 meters buffer				500 meters buffer			
Tree cover (%)	0.038**	0.041***	0.036**	0.037**	0.003	0.005	0.011	0.011
# hundreds of Jacarandas	0.023	0.031	0.040	0.024	0.061***	0.061***	0.058***	0.053***
# hundreds of trees	-0.001		-0.001	0.000	0.001**		0.001***	0.001**
Ratio of deciduous trees	0.010		0.007	0.011	-0.003*		-0.008***	-0.006**
# of Species	-0.082			-0.270*	0.236***			0.041
Shannon index	0.092			0.299**	0.069***			0.033
	750 meters buffer				750 meters buffer			
Tree cover (%)	0.057***	0.061***	0.054**	0.053**	-0.003	0.001	0.013	0.014
# hundreds of Jacarandas	0.009	0.016	0.022	0.013	0.038***	0.038***	0.036***	0.031***
# hundreds of trees	-0.001		-0.001	0.001	0.000**		0.001***	0.001**
Ratio of deciduous trees	0.014		0.007	0.018*	-0.004*		-0.012***	-0.007*
# of Species	-0.148			-0.491***	0.297***			0.032
Shannon index	0.113			0.454***	0.084***			0.085
	1km buffer				1km buffer			
Tree cover (%)	0.056**	0.064**	0.063**	0.055**	-0.007	-0.002	0.012	0.012
# hundreds of Jacarandas	0.013	0.018	0.022	0.015	0.025***	0.025***	0.023***	0.018***
# hundreds of trees	-0.000		-0.000	0.000	0.000*		0.000***	0.001**
Ratio of deciduous trees	0.004		-0.003	0.012	-0.005**		-0.014***	-0.007
# of Species	-0.030			-0.292	0.323***			0.073
Shannon index	0.235			0.440***	0.085***			0.100

* significant at 10%; ** significant at 5%; *** significant at 1%

Model 1: Includes only one tree cover variables at a time
Model 2: Use tree cover and the number of jacarandas
Model 3: Includes tree cover, number of jacarandas and deciduous ratio.
Model 4: Model 3 plus the Shannon index.

Figure 1: Real estate properties in the sample (apartments are in red, houses in blue).

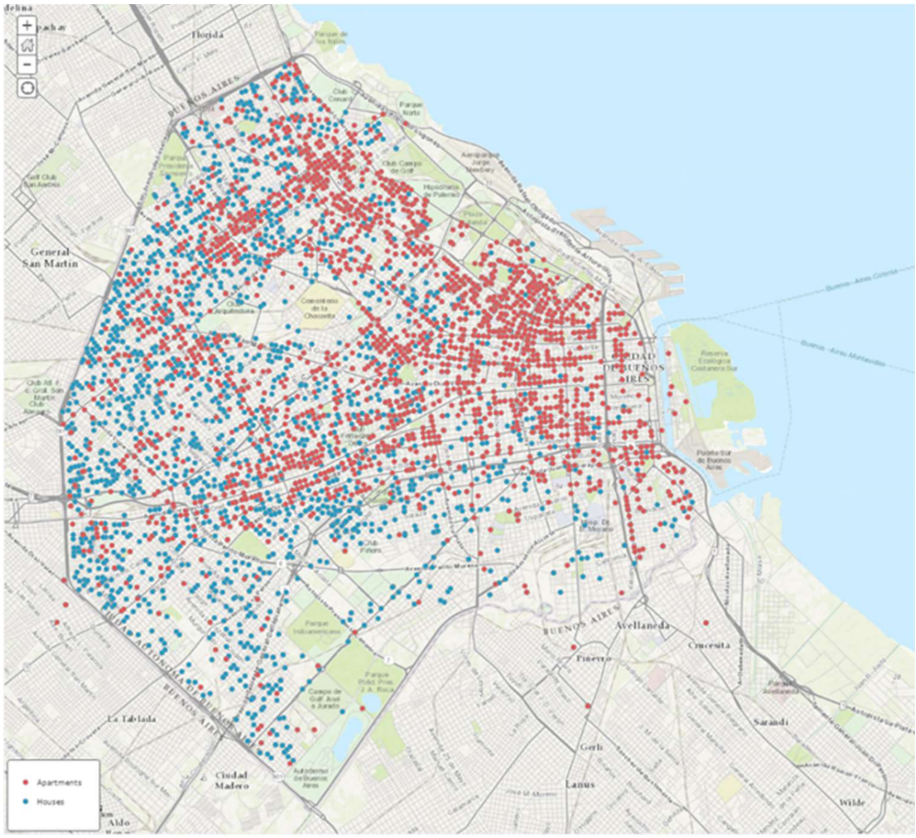
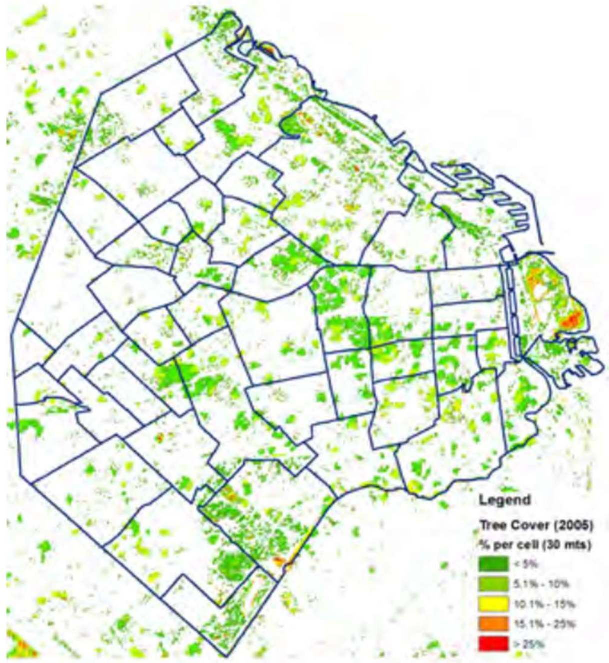


Figure 2: Urban tree cover in Buenos Aires City based on the Global Land Cover Facility (2010), measured as percentage of surface in a 30 meters by 30 meters cell covered by trees.



References

Anderson, L.M., H.K. Cordell, (1988). Influence of trees on residential property-values in Athens, Georgia (USA) - a survey based on actual sales prices. *Landscape and Urban Planning* Vol. 15(1–2), pp. 153–164.

Anselin L. (1988). Spatial Econometrics: Methods and Models. Studies in Operational Regional Science, Volume 4. Springer Netherlands.

Anselin, L. (1992). Spatial data analysis with GIS: An introduction to application in the social sciences. National Center for Geographic Information and Analysis, University of California, Santa Barbara.

Anselin, L. and A.K. Bera (1998). Spatial dependence in linear regression models with and introduction to spatial econometrics. *Handbook of Applied Economic Statistics,* A. Ullah and D.E.A. Giles, Eds., Marcel Dekker, NY, pp. 237–289.

Bolitzer, B. and N. R. Netusil. (2000). The impact of open spaces on property values in Portland, Oregon. *Journal of Environmental Management*, Vol. 59 (3), pp. 185–193.

Brander, L.M. and M.J. Koetse (2011). The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of Environmental Management*, Vol. 92(10), pp. 2763–2773.

Case, K. and R. Shiller (2003). Is there a bubble in the housing market? Brookings Papers on Economic Activity, Issue 2, pp. 299–342.

Cheshire, P. and S. Sheppard (1995). On the price of land and the value of amenities. *Economica*. New Series, Vol. 62, No. 246, pp. 247–267.

Cho, S., N.C. Poudyal, and R.K. Roberts (2008). Spatial analysis of the amenity value of green open space. *Ecological Economics*, Vol. 66, pp. 403–416.

Des Rosiers, F., M. Theriault, Y. Kestens and P. Villeneuve (2002). Landscaping and house values: An empirical investigation. *Journal of Real Estate Research*. Vol. 23(1-2), pp. 139–161.

EIU (2010). Latin American Green City Index 2010: Assessing the environmental performance of Latin America's major cities. The Economist Intelligence Unit. United Kingdom.

Friedman, M. (1962). Capitalism and freedom. Chicago, Illinois: University of Chicago Press.

Green Leigh, N. and S.L. Coffin (2005) Modeling the relationship among brownfields, property values, and community revitalization. *Housing Policy Debate*, Vol. 16(2), pp. 257–280.

Geoghegan, J. (2002). The value of open spaces in residential land use. *Land Use Policy*, Vol. 19, pp. 91–98.

Hartig, T. and U. Fransson (2009). Leisure Home Ownership, Access to Nature, and Health: A Longitudinal Study of Urban Residents in Sweden. *Environment and Planning A*, Vol. 41 (1), pp. 82–96.

Kitchen, J.W., and W.S. Hendon (1967). Land values adjacent to an urban neighborhood park. *Land Economics*, Vol. 43(3), pp. 357–61.

Lancaster, K.J. (1966). A new approach to consumer theory. *Journal of Political Economy*, Vol. 74(2), pp. 132–157.

LeSage, J. and R.K. Pace (2009). Introduction to Spatial Econometrics, CRC Press Taylor & Francis Group: Boca Raton, United States.

Luttik, J. (2000). The value of trees, water and open space as reflected by house prices in the Netherlands. *Landscape and Urban Planning*, Vol. 48(3-4), pp. 161–167.

Mansfield, C., S.K. Pattanayak, W. McDow, R. McDonald and P. Halpin. (2005). Shades of Green: Measuring the value of urban forests in the housing market. *Journal of Forest Economics* Vol. 11 (3), pp. 177–199.

Mayor, K., S. Lyons, D. Duffy and R. Tol (2009). A hedonic analysis of the value of parks and green spaces in the Dublin area. ESRI working paper No 331. Economic and Social Research Institute of Ireland.

McConnell, V. and M. Walls (2005). The value of open space: Evidence from studies of nonmarket benefits. Washington DC: Resources for the Future.

Roback, J. (1982). Wages, rents and the quality of life. *Journal of Political Economy*, Vol. 90(6), pp. 1257–78.

Rosen, S. (1974). Hedonic prices and implicit markets: Product differentiation in pure competition, *Journal of Political Economy*, Vol. 82(1), pp. 34–55.

Saphores, J, D. and W. Li (2012). Estimating the value of urban green areas: A hedonic pricing analysis of the single family housing market in Los Angeles, CA. *Landscape and Urban Planning*. Vol. 104, pp. 373–387.

Tyrvainen, L. and A. Miettinen (2000). Property prices and urban forest amenities. *Journal of Environmental Economics and Management*, Vol. 39, pp. 205–223.

Voicu, I., and V. Been (2008). The effect of community gardens on neighboring property values, *Real Estate Economics*, Vol. 36 (2), pp. 241–283.

Walsh, R. (2007). Endogenous open space amenities in a locational equilibrium. *Journal of Urban Economics*, Vol. 61, pp. 319–344.

Weicher, J. and R. Zerbst (1973). The externalities of neighborhood parks: An empirical investigation. *Land Economics*, Vol. 49(2), pp. 99–105.

Wolch, J. R., B. Jason and J.P. Newell (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough', *Landscape and Urban Planning*, Vol. 125, pp. 234–244.

Wu, J. (2014). Urban ecology and sustainability: The state-of-the-science and future directions. *Landscape and Urban Planning*, Vol. 125, pp. 209–221.