Trees under urban pressure:
A Case Study on understanding the effect of public street trees on property prices in highly urban Amsterdam

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Title	Trees under urban pressure: A Case Study on the value of public street trees on property prices in highly urban Amsterdam
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Abstract
This paper discusses the value of public street trees on property prices in Amsterdam, based on a hedonic approach. Trees can be found in all public green amenities and are vital for physical, mental and social well-being of people. However, over the past decade urban pressure has increased as green space has been replaced with new residential areas. This has led to an increasing concern with the development of urban areas and the availability of green spaces for future project development in fast-growing Amsterdam. Dutch housing "NVM" data is used, providing 100,503 observations of residential property transactions in Amsterdam and their characteristics. The public database of the municipality of Amsterdam (2019) provides data of 265,000 street trees and their characteristics. Results indicate that a 10% increase of trees per street (per 100m) adds a 0.03% to 0.05% premium on property prices, trees within 10-50 metre of a property adds a 0.02% to 0.05% premium to property prices. Of street trees, the Hawthorn tree shows a significant positive influence on property price. Furthermore, the presence of monumental trees in a street shows a stable significant positive influence on property price as well as monumental trees Linden, Plane, Oak, Acacia and Horse Chestnut. The findings will be useful for both urban planning and residential project development. Overall, there are no economic significant results in this study.

Keywords: Property value, hedonic price model, street trees, urban green space, home-buyers preference;

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1. INTRODUCTION

1.1. Motivation

Urban green space contributes to physical, mental and social well-being of people (Barbosa et al., 2007; Newton, 2007; Rutt & Gulsrud, 2016). It reduces CO2, improves air quality, reduces the heat island effect (1) (Mullaney et al., 2015; Pandit et al., 2013; Sander et al., 2010; Seamans, 2013), facilitates informal contacts and leads to increasing attachment of the physical environment of a place, which can lead to increasing mental health (Berg van den et al., 2015; Ruijsbroek et al., 2017). There are several amenities that urban residents' value: parks, open spaces and recreational facilities. Street trees are amenities which can be found in all of these amenities (Pandit et al., 2013; Sander et al., 2010). Street trees provide shade (thus reduce energy usage), stimulate social contacts, protect against soil erosion, have storm water benefits, reduce CO2, have air pollution benefits, provide a habitat for wildlife, make local air quality improvements and help with the reduction of the urban heat island effect (Mullaney et al., 2015; Pandit et al., 2013; Sander et al., 2010; Seamans, 2013).

Due to these benefits it is important to include public street trees in future city (project) developments and urban planning. The type of tree species should be carefully chosen with city tree planting (Pandit et al., 2013). Different tree species have different aesthetics and different characteristics, which gives each tree a direct effect on its environment. For example, the amount of volume of rainwater it intercepts, the fauna abundance and fauna diversity it creates (Mullaney et al, 2015). These reflect on the different value of trees and a different economic value: maintenance costs vary per tree species and have a different economic effect on its environment, such as surrounding properties.
The value between trees and properties is mostly calculated by using the hedonic price model, which is a 'non-market' valuation technique that shows the willingness to pay for a marginal change in the number of characteristics of a property. The method is popular to research the economic value of environmental amenities on property price (Pandit et al., 2013; Zhang & Dong, 2018). Past research found mostly positive relations between trees and property price (Pandit et al., 2013; Sander et al., 2010). The impact of 44 studies conducted in the US ranges from a 0.1% to 61% premium on property price (depending on location and tree coverage) (Siriwardena et al., 2016). A study in Quebec City, Canada, found that up to 30 trees per lot increases property price by 5%-15% (Des Rosiers et al., 2002). An Australian study found that broad-leaved trees increase property price by 4.27% (Pandit et al., 2013). Not many studies that have been conducted had sufficient data on individual trees, such as the tree type or height. With studies on tree canopy cover, such as on large urban forests, tree characteristics are not particularly necessary, but in studies on individual trees, such as trees alongside streets, tree characteristics give a more detailed analysis of the effects of these type of trees (Sander et al., 2010).

1: An urban heat island is an urban of metropolitan area that is significantly warmer and often has less wind than its surrounding rural areas. The urban heat island is caused by (high) human activity (Rafiee te al., 2016).

Due to different aesthetics and characteristics of trees, different trees give different economic value on dwellings thus are important to take into account (Mullaney et al, 2015).

FIGURE 1: Fredrik Hendrikstraat, Amsterdam. Source: Schlijper (2019).

FIGURE 2: Greenspace since 2003.
Source: Giezen et al., (2018)

The past decade, local benefits and economic values of trees are often poorly recognized by landowners and planners (Sander et al., 2010). Population growth and high urban pressure is leading to increasing concern in the development of urban areas and the availability of green spaces (Haaland & Konijnendijk van den Bosch, 2015; Jim & Chen, 2006; Matsuoka & Kaplan, 2008). Urban green space such as parks and street trees are being removed for housing and infrastructure even when urban green space is already limited (Haaland & Konijnendijk van den Bosch, 2015). Planners often do not know the willingness to pay of residents for urban green, implying the potential misunderstanding of the demand for urban green features (Zhong & Dong, 2018).

In Amsterdam, most streets and roads in Amsterdam are lined with trees, even traffic space has trees. The municipality of Amsterdam (2019) has more than 265,000 trees in maintenance and registered the trees and their characteristics in a public data base (Van der Hoeven & Wadl, 2015). However, over the past 15 years, Amsterdam has been experiencing a decline in green of around 550 to 600 soccer pitches, mostly in the form of agricultural area, sports fields and open green area (near roads and sidewalks, see figure 1) (Giezen et al., 2018). Even though the municipality plants new green spaces in the city (there is 37% more city park surface and public green compared to 2007), the amount of green space per person is dropping. Between 2015 and 2016, 28.5 hectares of green disappeared (ca. 60 soccer pitches). In 2006, the amount of green per person was 38 square metres, in 2015 31.9 and 2016 31.3 (see figure 2). The amount of green per person is not expected to be sufficient in the upcoming years especially due to the rise of new dwellings (and no demolishment) and therefore a lack of space for green (van

Zoelen, 2018). In 2019, Amsterdam will have the highest population ever and in 2039 the population is expected to rise to one million (OIS Amsterdam, 2018). This implies a current shortage of around 42.000 dwellings in the Amsterdam metropolitan area and is not expected to be solved in the upcoming decade (Anon, 2019).

This paper explores the value of public street trees on property prices in Amsterdam using the hedonic price model. Earlier research in residential neighbourhoods in The Netherlands showed that nature has the purpose to stimulate human interaction, and has important aesthetic value (Matsuoka & Kaplan, 2008). This directly relates to the value of this study which includes several reliable tree characteristics such as monumental trees, tree heights and tree species, unlike most studies. As mentioned, including tree characteristics is important to do a more detailed analysis of the (economic) effects of these type of trees on property price, for example, tree types can also have different characteristics, such as the amount of shadow or the aesthetics of a tree, which can be either be appreciated or not be appreciated by a home owner. This gives a very detailed insight on the influence and willingness to pay for street trees. The study will thus indicate the effect of street trees in quantitative terms and thus home buyers' preferences. The results of this research can be beneficial for urban planners, architects and urban residents.

1.3. Research problem statement

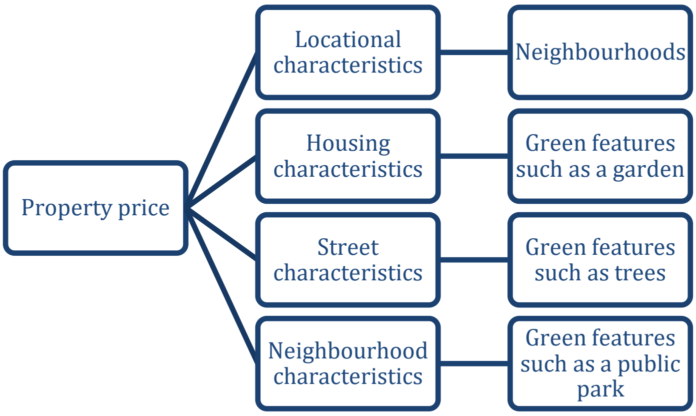

FIGURE 1: Conceptual model explaining the structure of the research and variables. Source: Author (2019); Zhang & Dong (2018).

The measurement and definition of green space varies across literature, which makes the results of past studies difficult to generalize (Panduro & Veie, 2013). The value of trees is difficult to measure: trees are a non-use value and an indirect service. The consumption of a tree also does not reduce the availability for someone else. Trees are also non excludable, everyone who walks by is a consumer, yet trees are not actually in use (Wolf, 2007). The value of a public tree is therefore highly locational dependent**.** In countries like the United States and Australia, trees function mostly to provide shadow

(Sander et al., 2010) and proximity to large urban forest area can lead to a decrease of property price due to a risk of forest fires (Siriwardena et al., 2016). As there has not been a case study on Amsterdam yet and studies with tree characteristics are limited, it is valuable to do research. The research is also valuable because the municipality of Amsterdam takes a lot of actions to make the city an example of green urbanism (Gilderbloom et al., 2009). Amsterdam also has a so called 'Green Agenda' to improve the quality of urban parks, more green space in the city for cooling and water storage, more and better green space in neighbourhoods, increased proximity to green space by planting trees and front gardens (Giezen et al., 2018). This study might give suggestions what type of trees to plant.

This leads to the main research question: *In what way influence public street trees property prices in Amsterdam?*

This question will be answered by the regression analysis of the NVM property transaction data and the (tree) database of the Municipality of Amsterdam. Figure 1 shows that a property has several groups of characteristics, this study researches one type of street characteristics: trees. This study includes several reliable tree characteristics monumental trees, tree heights and tree species, unlike most studies. Including these characteristics gives a very detailed insight on the influence of street trees. This data will be supported by background information of existing academic literature on for example the relationship between urban green amenities and the benefits of trees such as the shadow trees provide. Some examples of these studies are that of Siriwardena et al. (2016), Donovan & Butry (2010), Sander et al. (2010) and Luttik (2000). The study of Luttil (2000) will be discussed in the theory section and argues that environmental amenities do not exclude each other.

As the main question, the sub question will be mainly answered by regressing the NVM and tree data, which has a variety of property and tree characteristics. The following sub question will be answered: *What housing characteristics influence the value of street trees on a property price?* To support the regression analysis, this question will also be answered with the background information of existing academic literature of Wolch et al. (2014) and Luttik (2000), which for example briefly discuss the combination of several environmental characteristic on property price. Additional information on public trees and public green in Amsterdam will be used, such as the characteristics of the 15 most common tree species in Amsterdam.

The remainder of this paper is organized as follows. Section 2 describes our conceptual model and section 3 our empirical approach. Section 4 describes the data and the exploratory analysis. Section 5 presents the results, and section 6 concludes.

2. THEORY

Matsuoka & Kaplan (2008) have studied literature contributions of the journal Landscape and Urban Planning between 1991 and 2006 that focus on how people interact with the urban environment. Out of all the literature, the importance of human interaction with nature in an urban area is the most prominent topic. The authors argue that ongoing urbanization is a threat for nature and that the importance of nature in urban areas is often not well understood by city planners and landscape designers. For example, the economic values of street trees are often underappreciated, while the costs of damage by trees cause are widely reported (Matsuoka & Kaplan, 2008). Due to the loss of green space in urban areas there is a need for additional research on the effects of urban green space (private and public) in quantitative and qualitative terms, especially in areas less researched so far (from local to city scales) (Haagland & Konijnendijk van den Bosch 2015). The importance of nature in cities needs to be better communicated so that city planners and landscape designers will understand the (economic) value again (Matsuoka & Kaplan, 2008).

The beneficial role of urban green space

Any vegetation found in the urban environment is called urban green space (UGS). UGS is a type of infrastructure that is a more varied service than any other urban services (Wolch et al., 2014). It is ranging from vegetated spaces to street trees, but also contains private gardens and public parks and contributes fundamentally to the quality of urban life (Noor et al., 2015; Rutt & Gulsrud, 2016). European studies found that UGS counteract problems associated with urbanization and climate change (Rutt & Gulsrud, 2016). The cooling characteristic of vegetation reduces the urban heat island effect, provides shade and therefore reduces energy use (Lin et al., 2015; Rutt & Gulsrud, 201). Other benefits are the reduction of noise pollution and flood mitigation (Lin et al., 2015). UGS also absorbs greenhouse gas emissions (Rutt & Gulsrud, 2016). As cities are responsible for approximately 75% of all the CO2 emissions, this is an important characteristic (Kucherova & Narvaez, 2018). UGS is even linked with economic and social well-being of people: it is a space for social interaction and physical activity and boosts the human immune system (Gatzweiler et al., 2016; Rutt & Gulsrud, 2016). Urban citizens benefit directly if the UGS is available near where people live, work and spend their free time. Pearlmutter et al (2017), suggests residential areas to have green within 150 metres of a home and larger green space within 400 metres.

UGS can be divided into public and private space. Public green space are amenities that include parks and reserves, sporting fields, riparian areas like stream and riverbanks, greenways and trails, community gardens, street trees, and nature conservation areas, as well as less conventional spaces such as green walls, green alleyways, and cemeteries (Wolch et al., 2014). Street trees are amenities which can be found in all public green amenities (Pandit et al., 2013; Sander et al., 2010). Street trees are often a part of public street greenery, which is urban green infrastructure that exists of grass, shrubs and trees alongside streets and roads. Public street greenery can have recreational functions, ecological functions, can reduce noise pollution or purity the air or solely 'beautify' the streetscape. For example, trees can reduce the oppressive feeling that high-rise or high-density buildings give (Zhang & Dong, 2018).

The beneficial role of street trees

The role of urban trees is tied with both natural and man-made systems (Pearlmutter et al, 2017) and have environmental, pshycho-socio-cultural and economic benefits. First off, trees protect against soil erosion and have stormwater benefits. The tree roots, leaf litter and vegetation around the tree removes pollutants, sediment and nutrients from the stormwater. In Manchester UK, street trees reduced runoff from asphalt by 62%. The water infiltration into a tree pit of a public tree has a significant role into the reduction of surface water runoff, especially because the reduction by street trees is more than was possible by interception (Armson et al., 2013). Trees also have CO2 and air pollution benefits, provide a habitat for wildlife, make local air quality improvements and help with the reduction of the urban heat island effect (Mullaney et al., 2015; Pandit et al., 2013; Sander et al., 2010; Seamans, 2013). Increasing urban forests and parks are the highest ranked tools against heat stress (Pearlmutter et al., 2017). Trees provide shade on buildings which lowers the inside temperature (Pandit & Laband, 2010). By increasing street trees and locating them in sun exposed locations that are prone to heating, the temperature lowers and reduces thermal stress for pedestrians (Pearlmutter et al., 2017). Second, pshycho-socio-cultural benefits include the support of healthy urban communities and positive social impact. Trees also reduce stress and provide shelter. Finally, economic benefits include trees providing shade and therefore saving energy (Mullaney et al., 2015; Pandit et al., 2013; Pandit & Laband, 2010; Sander et al., 2010; Seamans, 2013). Trees that provide 19.3% (the sample mean of the study) shade over a property in Alabama USA, can reduce 21.22$/a month (9.3%) electricity costs in the summertime compared to a property which has no shade by trees. Trees that cover 50% shade reduce 32.3 dollar a month (14.4%). Another US study found that 2 trees shading the east part of a property reduces the annual energy use for cooling by 10%-50%. Trees also increase energy costs in the winter due to the shade they provide in winter mornings. Tree species such as the Red Maple, the Tulip Popular, the Water Oak, the Black Oak and the Pin Oak are broad leaved in the summer and lose their leaves in the wintertime. Due to the trees having less shade in the wintertime, homeowners do not have the higher heating costs (Pandit & Laband, 2010). Furthermore, trees and vegetation could be an excellent solution for stormwater regulation and water purification if managed properly. This should be used to guide stormwater policy and could have economic value, especially in European cities. The largest contribution in monetary value was the effect of stormwater benefit of 48USD per tree, which was significantly higher than the benefit in the US. The Canadian Popular, narrow leaved Ash, black pine, European Hackberry and the Plane were the trees who caught the most rain, around 5m3 per year. Therefore, maintenance of these trees is crucial to maintain the benefits (Pearlmutter et al, 2017).

Street trees and the influence on property price

A property is a heterogeneous good, it is a combination of its characteristics and makes housing a choice of its characteristics (Fan et al., 2006). The characteristics can be both internal and external and can take on various scales, such as locational scale, neighbourhood scale or even at city scale (Fan et al., 2006, Panduro & Veie, 2013). These characteristics can be housing characteristics, such as age and building types, locational characteristics such as geographical locations such as the distance to the city centre. For example, in a competitive housing market, buyers tend to be willing to pay more for houses with high value amenities and the longer the distance to the city centre the lower the property price. Furthermore, there are neighbourhood characteristics which implies e.g. the distance to parks, urban green spaces, schools, metro stations (Zhang & Dong, 2018).

The hedonic price model is a generally used tool to measure the economic effects of environmental amenities such as the accessibility to wooded areas, urban parks, other public green spaces or the value of individual trees such as the tree canopy cover (Donovan & Butry, 2010; Zhong & Dong, 2018). The hedonic price model is a non-market valuation technique, which shows the willingness to pay for a marginal change in the number of these characteristics (Pandit et al., 2013). The method has the purpose of (statistically) explaining the determinants of the property price. *"By regressing the transaction prices of housing against corresponding housing characteristics, one can estimate the contribution of the characteristics to prices—i.e. the implicit market valuation of these characteristics—and identify the significant characteristics affecting the prices*" (Fan et al., 2006: 2302). The hedonic price model can thus be used to determine the relative importance of various elements (such as environmental or internal characteristics), to derive demand functions for housing and to test alternative theories of residential location (Maclennan, 1977).

Studies that focus on solely (street) trees instead of public parks and urban green spaces are relatively new. The past three decades the hedonic price method has been a popular tool for the research of trees (Donovan & Butry, 2010; Fan et al., 2006). There are generally two types of studies: individual trees and canopy cover. Both types of study can be in the form of an urban forest, like a park, or non-concentrated private or public tree coverage in a neighbourhood, city or on an even larger scale (Donovan & Butry, 2010). Tree canopy cover has the disadvantage of excluding the streetscape profile viewed by humans (Zhong & Dong, 2018) and it does not give insight on the effect of individual trees and characteristics of the trees, such as the tree type or height (Sander et al., 2010).

Street trees often provide benefits for residential property values, thus for homeowners (Pandit et al., 2013; Sander et al., 2010). The accessibility to public street trees and public green space throughout a city tends to be uneven (Wolch et al., 2014). In residential neighbourhoods most trees are located on private properties (Siriwardena et al., 2016). Higher income groups tend to live in more spacious and/or suburban areas with more access to green and tend to have a good level of tree coverage from both public and private green space (Lin et al., 2015; Wolch et al., 2014). In Minnesota US, 5 or more trees on private properties have a 3.5%-4.5% price increase (Mei et al., 2017). In the California US, residential properties with tree cover increase the sales price from 6% to 9%. Landscaping with trees increases 3.5%-4.5% (Noor et al., 2015). Research in the Randstad area in the Netherlands has shown that environmental characteristics do not exclude each other in the additional value to the property price. If a house has a garden, has a view over a lake and is adjacent to a green area, all three of those features will add value to the property price (Luttik, 2000). Disadvantaged groups are more reliant on public green space, such as parks, but not all parks are equally maintained (Lin et al., 2015; Wolch et al., 2014). This makes tree coverage related to the social status of a neighbourhood (Lin et al., 2015). *"…But within cities, green space is not always equitably distributed. Access is often highly stratified based on income, ethno-racial characteristics, age, gender, (dis)ability, and other axes of difference*" (Wolch et al., 2014: 235). The reliance on public green space when private is absent does not have to be a disadvantage to the property price. It seems that people generally prefer to have tree cover as a public good near amenities rather than at home as a private good (Siriwardena et al., 2016). Pandit et al. (2013) studied trees on three locations in Perth, Western Australia: private space, public space and neighbouring private space, and found that trees on private properties tend to not increase the property value because they might block the view, take in too much space or take too much maintenance. Large trees can damage infrastructure or take in (private) space that could have been used otherwise (Pandit et al., 2013). Also, the maintenance costs are for the owner while the community can also enjoy the benefits of the tree(s). This makes trees on private properties sub-optimal, (Sander et al., 2010; Siriwardena et al., 2016) Street trees can also have negative externalities, such as the block of sunlight, attract too much wildlife, break apart during heavy weather circumstances (Siriwardena et al., 2016). However, street trees citizens do not have direct costs. Pandit et al. (2013).

Earlier research on the value of public tree coverage on property price found that in more central urban areas, larger tree coverage tends to be valuable while in more suburban and decentralized areas, a higher frequency of less tree coverage is valuable. Trees tend to be more valuable when they are scarce rather than in areas with a large urban forest (Siriwardena et al., 2016). Siriwardena et al. (2016) identified 56 hedonic property value studies with either forest characteristics, canopy cover or individual tree characteristics as explanatory variable and chose the 44 studies which were conducted in the US. The study found that 64% of the observations have positive impact on property price, ranging from 0.1% to 61% increase (depending on location and tree coverage). The study also found that people prefer older trees, which implies that the trees provide more shade and are also more visually appealing (Siriwardena et al., 2016). It is important to mention that in this analysis the definition of an old tree is a tree of more than 120 years old. This is questionable as this means a 100-year-old tree is considered as young.

Sander et al. (2010) researched the relationship between urban tree coverage and property price using a hedonic price model and used GIS to estimate neighborhood variables. The results show that people living in single family properties (in urban areas) value tree coverage within 100m and 250m (Sander et al., 2010). In a Californian study, street trees were found to have with $91.89 per tree the single largest benefit of all the US, which is related to the higher median home sales price (McPherson et al., 2016). The Australian study also found that home buyers may value different types of trees for different reasons. Some trees provide greenery all year long, other trees provide a lot of shade in the summertime. The study also found that broadleaved trees generally increase property price and that palm trees have no effect. Solely broad-leaved trees at the street increase the property value by 4.27% (Pandit et al., 2013). Garrod & Wilis (1992) also found that in Great-Brittan, broadleaved trees have a positive impact on property price, of approximately 43 pounds per tree. Especially for extra price and profit for property developers this benefit could add up, not per se for citizens as this premium is not seen in the property price nor for environmental benefits as the growth in the demand for broadleaved trees by citizens is unlikely to increase.

Donovan & Butry (2010) used a hedonic price model to estimate the effects of street trees in the sales price in Portland Oregon, which has around 550,000 inhabitants. House price is regressed against variables that describe the property, the neighbourhood and the environmental amenity. They found that the number of trees fronting the property and crown area within 30,5 meter of a house has a positive influence on the sales price (Donovan & Butry, 2010). Des Rosiers et al. (2002) studied 760 single family homes sold in Quebec City, Canada between 1993 and 2000 and found that up to 30 trees per lot increases property price by 5%-15%. A dense tree cover, with more than 30 trees, can even decrease property price by 2%. With more expensive houses smaller trees increase property price, larger trees decrease property price (Des Rosiers et al., 2002).

Trees and public green in Amsterdam

Natural vegetation and trees are the most desirable element in outdoor areas in residential neighbourhoods in The Netherlands, neighbourhoods featured with water and trees encourage walking for health purposes. The government of the Netherlands recommends 75 sqm urban green for every dwelling and should be within 500 metres of every property (Pearlmutter et al., 2017). Amsterdam has a variety of land uses throughout the city, including built-areas, parks, forest and agricultural area (Rafiee et al., 2016), but Amsterdam never reached a sufficient amount of green per person. In 2000, there was around 14 square metres per person (Beatley, 2000). In 2006, the amount of green space per dwelling in Amsterdam was 38 sqm, in 2016 the amount of green space dropped again to 31.3 sqm (without sports fields and agricultural area) (Pearlmutter et al., 2017). The past few years the urban green space has dropped by 11%. This drop can be explained by the high population growth of 7% together with an increase of the number of dwellings of 7% (Giezen et al., 2018).

Most streets and roads in Amsterdam are lined with trees, even traffic spaces have trees (Van der Hoeven & Wadl, 2015). Still, the green space has been unevenly distributed throughout the city. Amsterdam has a compact city program since 1978 as a result of high population growth. Development of eastern docklands area started, which is a typical example of the Amsterdam growth policy. These compact growth policies have led to the loss of neighbourhood greenspaces. IJburg is an excellent example, which is a new eastern dock island with almost no green and very few trees (Beatley, 2000).

In the city centre however, there is open and public green space available, such as the Museumplein, the Vondelpark, the Westerpark and the Amsterdam woods (Gilderbloom et al., 2009).
The municipality of Amsterdam takes a lot of actions to make the city an example of green urbanism (Gilderbloom et al., 2009). The municipality of Amsterdam maintains all of the city parks and public green and has around 300,000 trees in maintenance (Kopnina, 2015). Amsterdam also has a so called ‘Green Agenda’ to improve the quality of urban parks, more green space in the city for cooling and water storage, more and better green space in neighourhoods, increased proximity to green space by planting trees and front gardens (Giezen et al., 2018).
There is a variety of opinions in academic research whether this shortage of green, and especially of trees, causes the fact that Amsterdam has a strong urban heat island compared to other European cities, which is caused by the vast build-up and densly populated areas in Amsterdam* (Rafiee et al., 2016). According to Rafiee te al. (2016), trees mitigate the Urban Heat Island (UHI) in Amsterdam. Trees leave shadow on streets and roads and cool off the surface and show the highest effect within a radius of 40 metre (Hoeven van der & Wadl, 2015; Rafiee te al., 2016). This implies that trees influence the energy balance of the city and therefore have an important influence on the climate of the city. The authors conclude that either 4 large trees, 20 medium trees or 90 smaller trees can reduce one-degree Celsius in Amsterdam and that results with temperatures above 35 degrees Celsius can potentially have even larger impacts (Rafiee et al., 2016). However, according to Keuken & van der Valk (2010), streets with high trees and especially with a large canopy cover can also have negative effects. A high tree canopy cover can also lead to a higher surface temperature because the heat cannot escape (Keuken & Van der Valk, 2010). Van der Hoeven & Wadl (2015) argue that, especially in the central area of Amsterdam, the clear concentration of high temperatures in the city is caused by the increasing energy usage due to bad energy labels of buildings. Therefore, improving the energy label of a building is preferred rather than planting extra trees (Van der Hoeven & Wadl, 2015).
Keuken & van der Valk (2010) did a case study on the effect of air pollution in a closed canopy street, the Jan van Gaalen street, in Amsterdam. The authors found that compared to a period without leaves, periods with leaves reduce the ability of ‘fresh’ air to come in the street-canyon, which consequently leads to leaves increasing traffic emissions and this increase levels of air pollution. This implies that ventilation is more important that the ability of trees to absorb pollution (Keuken & Van der Valk, 2010).

*Measured during a heat wave in 2006.

3. DATA & METHOD

3.1 Context

The study is a case study of the Municipality of Amsterdam, in North-Holland, the Netherlands. The region covers 219,49 km2 and has more than 820,000 inhabitants with 5,042 inhabitants per km2. The land covers 24% agricultural land, 16% living area, 10% water wider than 6 metre, 6% road traffic area, 8% business and industrial trade areas and 4% parks and public gardens (Gemeente Amsterdam, 2019). Amsterdam has 8 city districts, 225 practice areas, 99 quarters and 481 neighbourhoods, which are used as a variable in the regression of this thesis and are listed in table 17.

This research is a quantitative research supported with academic literature. For the quantitative analysis of this thesis, NVM Data of 100,503 property transactions of Amsterdam, data of 265,000 public trees provided by the municipality of Amsterdam has been used. Additionally, a few other datasets of the Municipality of Amsterdam are used to enrich the data for this research. A dataset of 2,615 monumental trees owned and maintained by the Municipality of Amsterdam is used, data of public sports fields are used and a dataset of public metro and tram stops is used, all of these datasets are provided by a public data source of the Municipality of Amsterdam (City of Amsterdam, 2019). The NVM data has been filtered by deleting missing values or unrealistic data. For example, properties with floor space below 30 and above 3000 have been deleted, and properties with more than 4 floors or 10 rooms have been deleted. A summary of all variables can be found in table 1 descriptive statistics. Figure 2 shows a map of NVM of the property prices from low to high (from light red to dark red).

FIGURE 2: Map of the NVM data (low red, low transaction price to high; FIGURE 3: Map of the tree data. Source: Municipality of Amsterdam (2019).

The tree data from the Municipality of Amsterdam is measured from 2006 to 2016. Figure 3 shows a map of the tree data, made with GIS (Geographical Information System). The map shows that the trees are situated all over Amsterdam, there are trees in all of the 481 neighbourhoods (see the distribution of tree heights and species on page 17 and 18; more detailed maps of trees per city neighbourhood are in the appendix on page 60). All of the registered trees are under maintenance of the municipality of

Amsterdam. It is important to note that there are more trees in Amsterdam as not all trees are registered. Trees on graveyards, allotment gardens, the Amsterdam woods and in an around sports fields are not registered. This is however not a huge influence on the results of this study as the majority of these type of trees are not in the same street as a property nor are these types of trees public green, they are private green as graveyards and allotment gardens are private property. The trees of the Amsterdam woods are around 150,000 trees, the municipality of Amsterdam owns these trees but are situated on the municipality of Amstelveen. Therefore, the trees are not registered and also not important to include in this thesis as this thesis focuses on the municipality of Amsterdam. The municipality of Amsterdam estimates that there are in total one tree per person in Amsterdam. The year planted is also registered, however this is mostly not the 'birthyear' of the tree but rather the year planted on its current place. Often these trees have spent their first years on another place, which can even get up to 5-15 years. Adding to that, some trees have been replanted after they have been registered. This makes the plant year data not indicative for the age of the tree. The true position of the trees can also differ from their actual position and can differ from 10cm to 10 metres. Another weakness important to note is the difference between trees that cannot be registered in the data, such as the street view that can be different. Streets that have canopy cover over the street have a very different street view than trees who do not have that. This can be partly solved by including tree types and tree heights, which I did.

To prepare for the regression analysis, the tree data has been combined with BAG address data to list on which street every tree is situated. Then, the tree data is combined with the NVM data based on street names and zip codes. Figure 4 shows an example of combining the tree and NVM data. The yellow arrow shows how the green dots, the trees, are assigned to the nearest red dots, the NVM property transactions. The total number of trees per street is also measured. If, for example, trees are assigned with GIS based on geographical location to the Ferdinand Bolstraat, every property transaction of NVM in the Ferdinand Bolstraat street is assigned with those trees. This tells us how many trees are situated in the Ferdinand Bolstraat. For example, street 'S-Gravenhekje has a total of 5 trees. A few samples are checked with Google Maps (2019), are seem all to be correct. There are 1,185 streets with no trees. I assume in this study that trees on private properties no dot have externalities on surrounding properties or the street and therefore are mostly not influential on surrounding property prices. However, some streets could be full of private trees and therefore look rich in trees and give shadow on a street, but in reality, none of them are from the municipality of Amsterdam, so the data will have a 0 (see figure 5 for an example). This makes the study not fully reliable. A property can have multiple trees in one street, every tree can also be a different species. Therefore, the 15 most common tree species are counted and summarized for every tree species, this is also done for the height of the trees.

FIGURE 4: Designation of trees in the same street as the NVM transactions. Maps

FIGURE 5: ‘S-Gravenhekje, Amsterdam. Source: Google (2019).

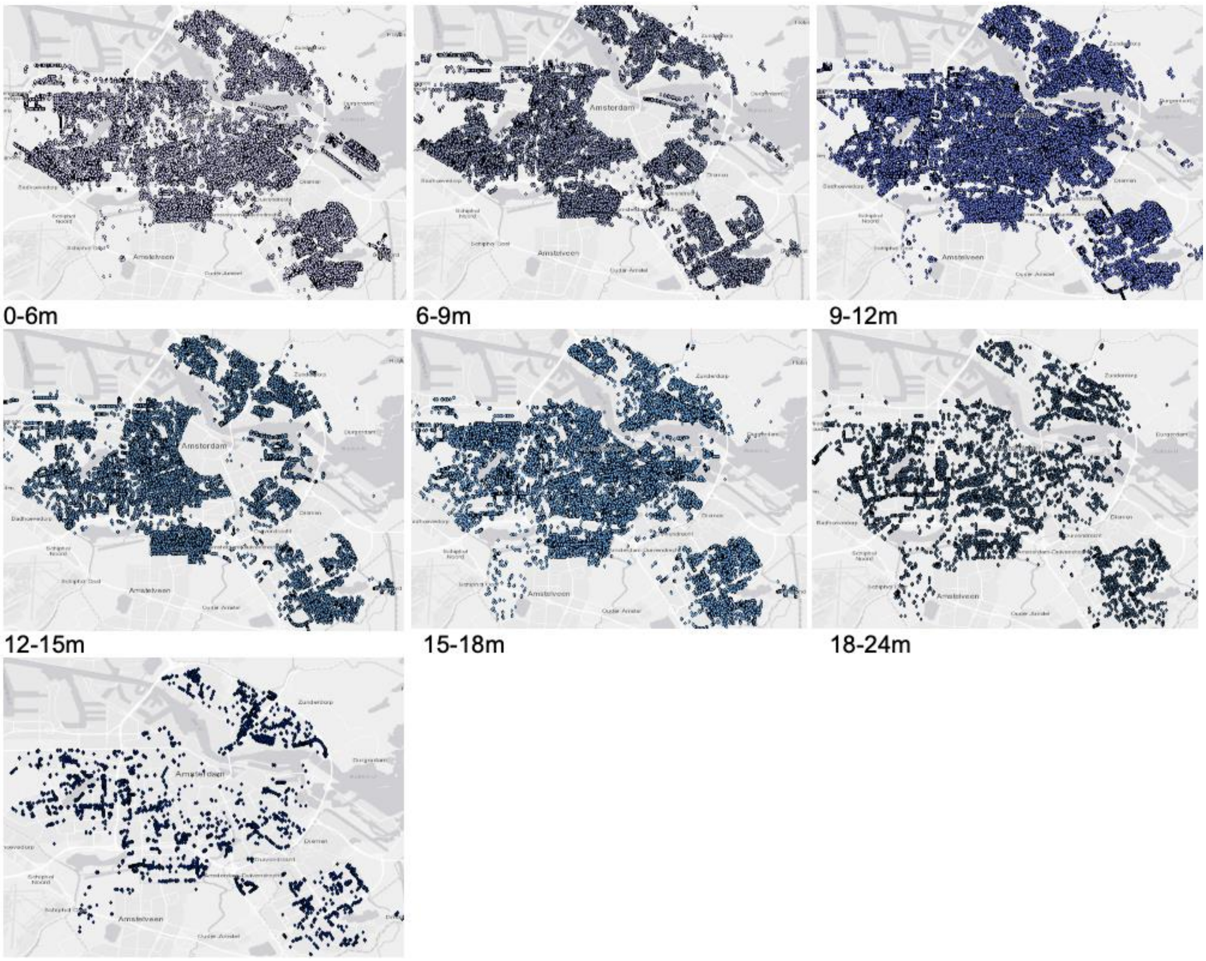

FIGURE 6: Geographical location of every tree height category. Source: Municipality of Amsterdam (2019).

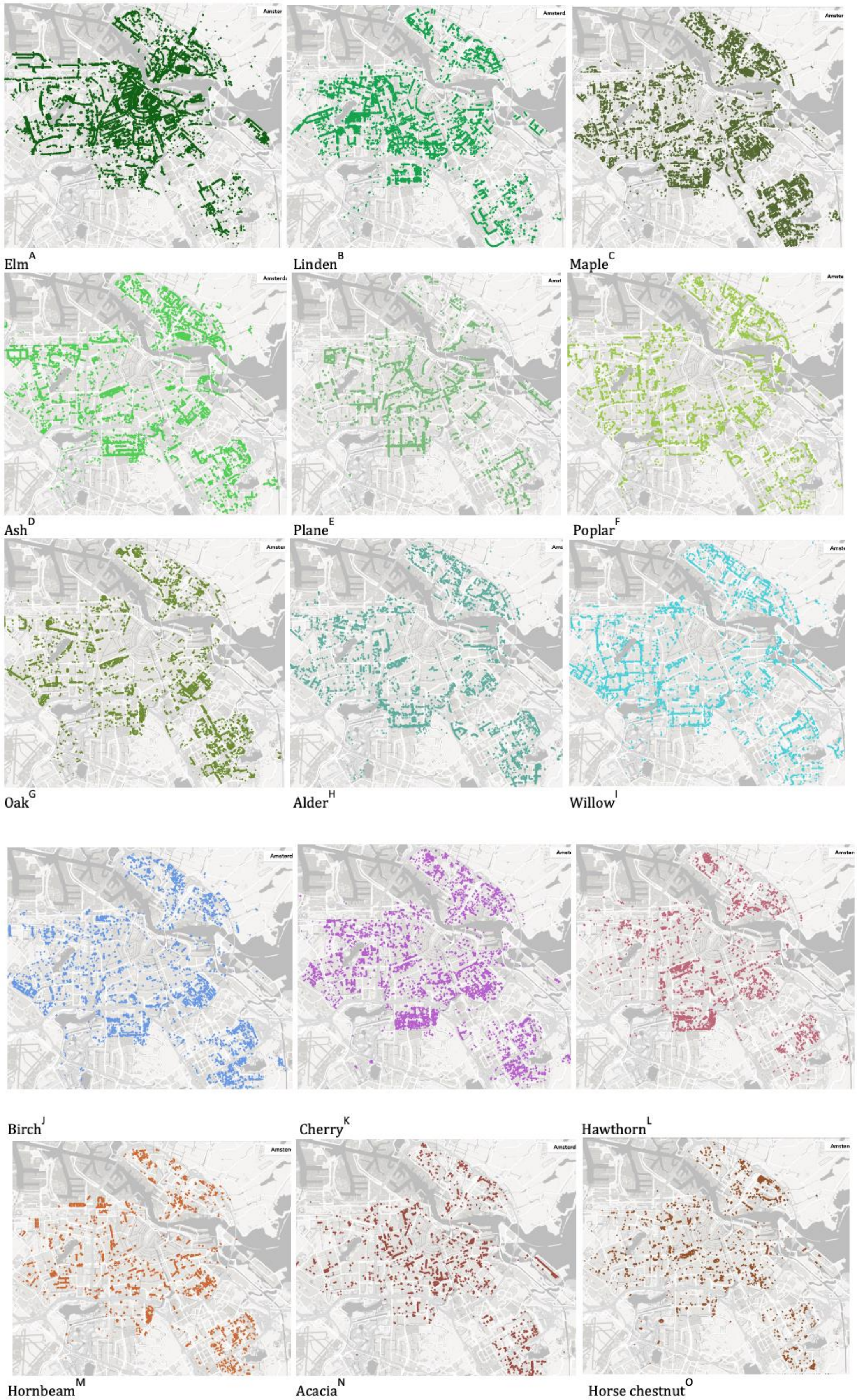

FIGURE 7: Geographical location of tree species. Source: Municipality of Amsterdam (2019).

3.2 Descriptive analysis

TABLE 1: DESCRIPTIVE STATISTICS

DEPENDENT VARIABLE		Mean	SD	Min	Max
Ln. Property price (€)	(continuous quantitative variable)	289,303.4	173,252.6	45,000	2,495,000
LOCATION CHARACTERISTICS					
Neighbourhoods	(ordinal qualitative variable)	196,2747	116,5822	1	403
HOUSING CHARACTERISTICS					
Ln. Total liveable surface (M2)	(continuous quantitative variable)	85.1306	36.28845	30	350
Building period	(dummy variable)	3.852345	2.660505	0	9
Apartment	(dummy variable)	1.886295	0.3174541	1	2
No. Rooms	(discrete quantitative)	3.241342	1.185919	1	10
No. Floors	(discrete quantitative)	1.423418	0.7086893	1	4
Parking spot, cohort or garage	(dummy variable)	0.0777936	0.2678478	0	1
Boiler or central heating	(dummy variable)	1.951685	0.2152813	1	3
Balcony or roof terrace	(dummy variable)	0.0526604	0.2233557	0	1
Garden	(dummy variable)	0.2342269	0.4235167	0	1
Ground lease	(dummy variable)	0.8881415	0.8418686	0	3
STREET CHARACTERISTICS					
Ln. Total trees per street (per 100m)	(continuous quantitative variable)	15.64321	20.60234	0	254
Total trees within 10m of property	(continuous quantitative variable)	0.7480075	1.30427	0	33
Ln. Total trees within 10-50m of property	(continuous quantitative variable)	18.55908	15.09813	0	162
Ln. Total trees within 50-100m of property	(continuous quantitative variable)	73.92156	45.65282	0	449
Total Elm (Ulmus) per street	(continuous quantitative variable)	16.18532	37.4275	0	286
Total Linden (Tilia) per street	(continuous quantitative variable)	8.850364	16.27147	0	126
Total Maple (Acer) per street	(continuous quantitative variable)	5.874238	12.75955	0	77
Total Ash (Fraxinus) per street	(continuous quantitative variable)	3.317568	10.08932	0	79
Total Plane (Platanus) per street	(continuous quantitative variable)	6.517547	16.83883	0	138
Total Popular (Populus) per street	(continuous quantitative variable)	2.347201	6.567875	0	95
Total Oak (Quercus) per street	(continuous quantitative variable)	2.703161	9.071066	0	76
Total Alder (Alnus) per street	(continuous quantitative variable)	2.354181	5.942276	0	47
Total Willow (Salix) per street	(continuous quantitative variable)	1.639079	4.243409	0	47
Total Birch (Betula) per street	(continuous quantitative variable)	1.778801	4.434724	0	43
Total Cherry (Prunus) per street	(continuous quantitative variable)	3.681066	8.610626	0	62
Total Hawthorn (Crataegus) per street	(continuous quantitative variable)	2.333875	8.47096	0	85
Total Hornbeam (Carpinus) per street	(continuous quantitative variable)	1.828837	6.01286	0	50
Total Acacia (Robinia) per street	(continuous quantitative variable)	3.248188	8.834248	0	98
Total Horse chestnut (Aesculus) per street	(continuous quantitative variable)	1.454291	3.955116	0	43
Dominant species per street	(dummy variable)	4.348736	4.171461	0	15
Tree up to 6m high	(continuous quantitative variable)	21.11257	52.97776	0	932
Trees 6 – 9m high per street	(continuous quantitative variable)	15.30843	32.41672	0	331
Trees 9-12m high per street	(continuous quantitative variable)	25.74888	51.35215	0	496
Trees 12-15m high per street	(continuous quantitative variable)	16.46694	39.83939	0	446
Trees 15-18m high per street	(continuous quantitative variable)	20.93498	45.25475	0	392
Trees 18-24m high per street	(continuous quantitative variable)	11.90821	33.1076	0	382
Trees 24m or higher per street	(continuous quantitative variable)	3.185095	11.41929	0	204
Dominant tree height per street	(dummy variable)	3.265885	2.776803	0	6
Dominant tree type within 100m	(dummy variable)	168.7995	100.3264	0	373
Dominant tree height within 100m	(dummy variable)	2.999098	2.312036	0	6
Total number of monumental trees per street	(continuous quantitative variable)	1.750366	5.682876	0	46
Monumental tree within 100m	(dummy variable)	0.2381222	0.4259364	0	1
Tree species of monumental tree	(dummy variable)	18.54704	39.31492	0	173
Tree planted 2 years before property sale	(dummy variable)	0.5170691	0.499711	0	1

NEIGHBOURHOOD CHARACTERISTICS					
Ln. distance to public nearest tree (m)	(continuous quantitative variable)	2.693263	1.137578	1	7
Distance to nearest park (m)	(dummy variable)	2.554521	1.052412	0	5
Ln. distance to nearest tram or metro (m)	(continuous quantitative variable)	3.668383	1.31304	1	8
Ln. Ln. distance to nearest public sports field	(continuous quantitative variable)	2.945285	1.614465	1	7
Observations					

N=100,503. M = metre.

Note that all trees are public trees, there are 1,185 streets without trees, 62,197 properties with no trees within 10 metres, 4,990 with no trees within 50 metres of their property and 650 properties with no trees within 100 metres of their property.

Variables with 'Ln.' in front of the variable are logged transformed. The total number of trees within 10 metres of a property is not normally distributed, when log transforming this variable, the variable is even skewer. Therefore, the variable is not log transformed. The total number of trees within 10-50 metres and 50-100 metres are normally distributed when log transformed.

3.3 Hedonic regression model

The model is a semi-log model. The dependent variable is a continuous variable and is log transformed to enforce a linear relationship with the predicted variable. The independent variables are both dummy variables and continuous variables. The data is panel data, is varies over time and over place.

$$\ln P_{it} = \beta o + \beta iLij + \beta iHij + \beta iSij + \beta iNij_{+} \varepsilon_{it} \qquad (1)$$

InPi is the price of the property I, beta 0 is the constant, Vector L denotes j Locational characteristics, H denotes Housing j characteristics, S denotes j Street characteristics, N denotes neighbourhood characteristics for the i-th observation. Epsilon ε is the error term.

Models 1 and 2 are basic models with locational characteristics, housing characteristics and neighbourhood characteristics. Model 3 contains a neighbourhood tree variable. Models 4 until 15 include independent tree variables, among which models 4 until 6 contain independent variables of trees within 100 metre of a property, models 7 until 11 contain independent variables of trees per street, models 12 until 14 contain independent variables of monumental trees. Models 15 until 17 contain interactions with the independent variable trees per street. Model 18 contains the most interesting and significant tree variables that can be combined in one model. Models 19 until 21 have categorical dependent variables of sales price between 0 up to 225,000 euro, 225,000 up to 500,000 euro and 500,000 euro and above.

4. RESULTS
4.1 Location, housing and neighbourhood characteristics

The first model exists of location and housing characteristics. The location characteristic are the 403 neighbourhoods of Amsterdam that are taken into the analysis as spatial fixed effects (the top left figure on page 61 shows all of the property locations taken into the analysis). In a competitive housing market, buyers tend to be willing to pay more for houses with high value amenities and the longer the distance to the city centre the lower the property price (Zhang & Dong, 2018). By including the neighbourhood variable, we ‘control’ for the differences between neighbourhoods, this implies that the value of trees (and other characteristics) are not influenced by price differences within neighbourhoods.

TABLE 2: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 1 Base model 1		Model 2 Base model 2		Model 3 Distance to nearest tree	
	β	Std. Err.	β	Std. Err.	β	Std. Err.
Ln. Total liveable area (M2)	.751***	.003	.751***	.003	.752***	0.003
Built 1500-1905 [a]	.014	.035	.015	.035	.015	.035
Built 1906-1944	-.014	.035	-.013	.035	-.013	.035
Built 1945-1970	-.140***	.035	-.140***	.035	-.140***	.035
Built 1971-1990	-.086	.035	-.086	.035	-.086	.035
Built 1991-2000	-.007	.035	-.005	.035	-.003	.035
Built after 2001	.074	.035	.074	.035	.074	.035
Neighbourhoods [b]						
Apartment [c]	-.057***	.003	-.056***	.003	-.056***	.003
No. Rooms	.025***	.0009	.025***	.0009	.025***	.0009
No. Floors	.005***	.001	.005***	.001	.005***	.001
Parking spot, cohort or garage [d]	.077***	.003	.076***	.003	.076***	.003
Boiler or central heating [e]	.189***	.003	.189***	.003	.189***	.003
Airconditioning or solar panels [e]	.336***	.042	.337***	.042	.336***	.042
Balcony or roof terrace [f]	.094***	.003	.094***	.003	.094***	.003
Garden [g]	.045***	.002	.045***	.002	.045***	.002
Permanent ground lease [h]	-.031***	.002	-.030***	.002	-.030***	. 002
Varying ground lease [h]	-.149***	.002	-.148***	.002	-.148***	.002
Ln. Distance to nearest public tree (m)					.0002	.0007
Ln. Distance to nearest tram or metro (m)			.009***	.001	.009***	.001
Ln. Distance to nearest public sports field (m)			-.003**	.001	-.003**	.001
Constant	9.110***	.038	9.065***	.044	9.070***	.044
R-squared	0.8470		0.8471		.8471	

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1 **p<0.05. ***P<0.01.
[a]Compared to unknown or built before 1500; [b] The results of the neighbourhoods are not listed due to the high number of neighbourhoods, all the neighbourhoods are listed in the appendix; [c]Compared to a house; [d]Compared to no parking spot, cohort or garage; [e]Coal or gas heating; [f]Compared to no balcony or roof terrace; [g] Compared to no garden; [h]Compared to no ground lease; [i]
*the results of the independent variables in this table are not included in the majority of the tables in further subsections of this chapter but are showed in the appendix.

The results of these neighbourhoods are not viewed in the results tables due to the high quantity, solely the neighbourhood names are listed in the appendix in table 17. The results of the first model show that a 10% increase in the total square meters significantly increases property price by 7.5% on a $p<0.01$ level. A property built between 1945-1970 significantly decreases property price a $p<0.01$ level. Compared to a house, an apartment significantly decreases the property price on a $p<0.01$ level. Positive capitalization into property values on a $p<0.01$ level are found for the number of rooms, the number of floors, the presence of a parking spot, having either a boiler or central heating or air-conditioning or solar panels, the presence of a balcony or rooftop and the presence of a garden. If a dwelling has a permanent or varying ground lease, the property price significantly decreases on a $p<0.01$ level. In Model 2 neighbourhood characteristics are added: the distance to the nearest tram or metro and the distance to the nearest sports field, both in metres. Results indicate that a 10% increase of the distance to the nearest tram or metro, the property price increases significantly on a $p<0.01$ level by 0.09%. A 10% increase of the distance to the nearest a public sport field significantly decreases to property price by 0.03% on a $p<0.01$ level. Important to note is that the addition of these variables has almost no influence on the other independent variables. Also, The R-squared of this model is slightly higher, as it shows that the independent variables explain 84.71% of the dependent variable, property price. Therefore, model 2 will be the basic model, all the independent variables will be included in all the basis of all the upcoming models.

Another neighbourhood characteristic is included in model 3: the distance to the nearest tree. This variable is calculated with GIS. The coefficient of the variable is positive, which means the further away the nearest tree the higher the premium on property price. Earlier research found that trees close to/on private properties do not increase the value because they might block the view, drop leaves, take in too much space or take too much maintenance (Pandit et al., 2013). The result of this variable does not necessarily confirm this theory as the coefficient of the independent variable is very small and not significant. It also does not reject it as the ‘distance to the nearest tree’ is not categorized. To conclude, the variable ‘distance to the nearest public tree’ has no significant contribution to property price.

4.2 Trees within 100 metre of a property

Models 4 until 6 are viewed in table 3 on the next page and show the results of tree (characteristics) within 100 metre of a property. It is interesting to see if trees in proximity to a property, 100 metre to be specific, have a different effect than trees in the entire street of a property. Model 4 shows the influence of the total trees within 10m, 10-50m and 50-100m, all of these variables are calculated with GIS. The descriptive statistics show that the maximum number of trees within 10m are 33 trees, within 10-50m are 162 trees and the maximum number of trees within 50-100m are 449 trees. Examples of streets with more than 400 trees within a buffer of 50-100m are the Bruinvisstraat in Amsterdam North and the Van Nijenrodeweg in Buitenveldert. The negative result of ‘total trees within 0-10 metre’ might explained by the negative externalities of trees close to a property, as they they might block the view, drop leaves, take in too much space or take too much maintenance (Pandit et al., 2013). The coefficient is however not significant and therefore not important in the contribution to property price. Donovan & Butry (2010) found that the number of trees fronting the property and crown area within 30.5 meter of a house has a positive influence on the sales price. This research shows similarities as results indicate that a 10% increase of the number of trees within 10-50m of a property, increases property price by 0.05% on a p<0.01 level. The results of this research might support this finding. Furthermore, results of a study conducted in the US show that people living in single family properties (in urban areas) value tree coverage within 100m and 250m (Sander et al., 2010). This is clearly not the case for Amsterdam, as only variable 'total trees within 10-50m from a property' is positively significant.

TABLE 3: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 4 Total trees within 0-100m		Model 5 Dominant tree height within 100m		Model 6 Tree species before property	
	β	Std. Err.	β	Std. Err.	β	Std. Err.
Total trees within 10m of property [a]	-.001	.0004				
Ln. total trees within 10-50m of property [a]	.005***	.001				
Ln. total trees within 50-100m of property [a]	-.006**	.002				
Most trees within 100m are 6–9m high [b]			-.0004	.003		
Most trees within 100m are 9-12m high [b]			.001	.003		
Most trees within 100m are 12-15m high [b]			.0003	.003		
Most trees within 100m are 15-18m high [b]			.005*	.003		
Most trees within 100m are 18-24m high [b]			.0009	.003		
Most trees within 100m are 24m or higher [b]			.002	.005		
Elm (Ulmus) before property					.0003	.002
Linden (Tilia) before property					.0005	.002
Maple (Acer) before property					-.001	.002
Ash (Fraxinus) before property					.0003	.003
Plane (Platanus) before property					.008*	.002
Popular (Populus) before property					-.010	.004
Oak (Quercus) before property					.001	.004
Alder (Alnus) before property					.006	.003
Willow (Salix) before property					.010	.004
Birch (Betula) before property					.007	.003
Cherry (Prunus) before property					.002	.003
Hawthorn (Crataegus) before property					-.0006	.004
Hornbeam (Carpinus) before property					.0008	.003
Acacia (Robinia) before property					.001	.003
Horse chestnut (Aesculus) before property					.002	.003
Constant	9.101***	.040	9.075***	.044	9.065***	.044
R-squared	.8466		.8467		.8472	

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1, **p<0.05, ***P<0.01.
The independent variables are compared to: [a]no trees; [b]tree before property 0-6m high; The variable of trees within 10m of a property is not logged transformed as the variable is even less normally distributed when log transformed. Note that all trees are solely public trees, no private trees are included in the analysis.

In model 5, the dominance of tree height within 100m of a property is added. Results indicate that trees that are 15-18m high are significant on a p<0.1 level. Each category of the tree height is mapped and shown on page 17. The maps clearly show that the quantity of the trees differ per category, as well as the location, which makes the value of tree heights slightly biased. For example, trees that are 15-18m high have a higher quantity compared to trees 18-24m high and 24m or higher, and not all tree heights are situated in the city centre. In model 6, the dominant tree species for trees within 100m of a property are added. Results indicate that the Plane has a significant influence on property price, though only on a p<0.1 level (maps of the distribution of tree species are shown on page 18).

4.3 Trees per street

Tables 4 and 5 show the analysis of trees per street. In models 7 until 10, the tree(s) (characteristics) are included. The total number of public trees per street is calculated, again with GIS. Not every street has the same surface and 5 trees in a street with a 500m surface might not have the same impact on neighbouring properties as a street with 5 trees and a 2000m surface. Therefore, the total number of trees per street is divided by the surface of every street and converted into total trees per 100m. Analyzing a few data samples of this variable with Google Maps street view (2019), the lower number of trees per street are often alongside roads and pavements, the higher number of trees per street are often on pieces of grass alongside apartment buildings or in lower densely populated areas, again with (more) pieces of grass. The street surface data is also gained from the public data source of the Municipality of Amsterdam.

TABLE 4: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 7 Trees per street		Model 8 Tree height		Model 9 Tree species	
	β	Std. Err.	β	Std. Err.	β	Std. Err.
Ln. trees per street (per 100m)	.007***	.0009				
Tree is 0 – 6 metres high			.00008	.00003		
Tree is 6 – 9 metres high			-.00002	.00003		
Tree is 9-12 metres high			.00005	.00004		
Tree is 12-15 metres high			.00001	.00002		
Tree is 15-18 metres high			.0001***	.00004		
Tree is 18-24 metres high			-.00009	.00003		
Tree is 24 metres or higher			.0001	.00009		
Elm (Ulmus) dominant in street					.008	.006
Linden (Tilia) dominant in street					-.003	.006
Maple (Acer) dominant in street					.0007	.006
Ash (Fraxinus) dominant in street					.001	.006
Plane (Platanus) dominant in street					.013	.006
Popular (Populus) dominant in street					.020	.008
Oak (Quercus) dominant in street					-0.13	.007
Alder (Alnus) dominant in street					.013	.007
Willow (Salix) dominant in street					.009	.008
Birch (Betula) dominant in street					-.002	.007
Cherry (Prunus) dominant in street					.015	.006
Hawthorn (Crataegus) dominant in street					.020*	.007
Hornbeam (Carpinus) dominant in street					.009	.007
Acacia (Robinia) dominant in street					.007	.006
Horse chestnut (Aesculus) dominant in street					-.005	.008
Constant	9.052***	.044	9.065***	.044	9.056***	.044
R-squared	0.8473		.8474		.8473	

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1 **p<0.05. ***P<0.01.

Results indicate that a 10% increase of public trees per street per 100m by 0.07%. This implies an increase of EUR 350 on a 500,000-property price. This result is the lower than any other study on the influence of trees on property price in the theory section of this paper. The biggest study on the influence of trees on property price (who researched 44 previous studies conducted in the US) found a premium ranging from 0.1 to 61% (Siriwardena et al., 2016). In model 8, the tree heights of every tree in a street are taken into the analysis. The model shows the same results as Model 5: trees of 15-18-metre-high are significant on an $p<0.01$ level (but with a lower coefficient). Note that the variable in model 5 shows the dominant tree height (within 100 metre) and the variable in model 8 is the height of every individual tree, so the more trees 15-18 metres high, the higher the property price premium. In model 9, dominant tree species per street are taken into the analysis. As mentioned, only the 15 most common species in Amsterdam are included in this research. Results show that the Hawthorn significantly increases property price, though only on a $p<0.1$ level. Table 15 with three types and their characteristics show that the Hawthorn tree is the smallest tree, can only get up to ca. 8 metres high and has a low shadow tolerance (see figure 8 for a Hawthorn tree in Amsterdam.

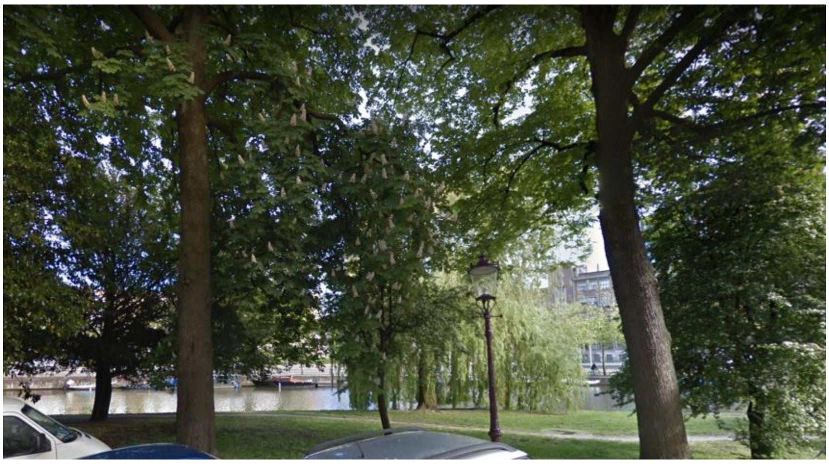

FIGURE 8: Three Hawthorn trees at the Spinozastraat, Amsterdam. Source: Google Maps. (2019).

TABLE 5: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 10 Dominant tree height		Model 11 Planted 2yrs before sale	
	β	Std. Err.	β	Std. Err.
Tree planted two years before property			.006***	.001
Most trees in street are 0-6m high	.009***	.001		
Most trees in street are 6–9m high	.003	.002		
Most trees in street are 9-12m high	.006**	.001		
Most trees in street are 12-15m high	.007**	.002		
Most trees in street are 15-18m high	.007**	.002		
Most trees in street are 18-24m high	.005	.003		
Most trees in street are 24m or higher	.001	.009		
Constant	9.028***	.0444	9.085***	.0385
R-squared	.8474		.8474	

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1 **p<0.05. ***P<0.01.

Model 10 in table 5 on the previous page shows that dominant street trees from 0-6-metre-high are significant on a $p<0.01$ level and trees between 9 and 18 metre have significantly positive influence on property price, on a $p<0.05$ level. The difference in results from model 8, could mean that street image of trees having the same height is important and adds a premium, which might have to do with aesthetics preferences (earlier research in residential neighbourhoods in The Netherlands showed that nature has the purpose for human interaction with nature and aesthetic preferences (Matsuoka & Kaplan, 2008)). Results of model 11 show that if a tree is planted 2 years before a property sale, it significantly increases the property price on a p<0.01 level. This implies that planting extra trees adds a premium to the sales price of a property.

4.4 Monumental trees

To better protect and maintain valuable trees, some trees are pointed as monumental trees. This means that the tree will not be cut down and that it receives extra attention and maintenance. A monumental tree is assigned as monumental when it is at least 50 years old and has one of the following characteristics: it determines the street image, it has cultural/historical value, it has a significant value to nature or is rare. The minimum circumference of the stick has to be at least 31cm. In reality, almost all of the monumental trees have the function of determining the street image and all trees are large. Due to tree illnesses and storms, the eldest tree is only 250 years old. Monumental trees older than 100 years only situated in city center, monumental trees younger than 50 years (only) in outside areas of the city. The eldest trees are situated alongside the canals of Amsterdam (Municipality of Amsterdam, 2019).

TABLE 6: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 12 Tree within 100m		Model 13 Total trees per street		Model 14 Tree species	
	β	Std. Err.	β	Std. Err.	β	Std. Err.
Monumental tree in within 100m	.020***	.001				
Total monumental trees per street			.0016***	.0001		
Monumental tree is Elm (Ulmus)					.012	.006
Monumental tree is Linden (Tilia)					.029***	.002
Monumental tree is Maple (Acer)					.012	.005
Monumental tree is Ash (Fraxinus)					.012	.012
Monumental tree is Plane (Platanus)					.014***	.003
Monumental tree is Popular (Populus)					.008	.006
Monumental tree is Oak (Quercus)					.027***	.007
Monumental tree is Alder (Alnus)					-.080***	.016
Monumental tree is Willow (Salix)					.005	.007
Monumental tree is Birch (Betula)					.014	.003
Monumental tree is Cherry (Prunus)					-.085***	.020
Monumental tree is Hawthorn (Crataegus)					-.025	.035
Monumental tree is Hornbeam (Carpinus)					.039	.017
Monumental tree is Acacia (Robinia)					.058***	.013
Monumental tree is Horse chestnut (Aesculus)					.020**	.006
Constant	9.076***	.044	9.067***	.044	9.066***	.044
R-squared	.8474		.8473		.8475	

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1, **p<0.05, ***P<0.01.

As earlier research in residential neighbourhoods in The Netherlands showed that nature has the purpose for human interaction with nature and aesthetic preferences (Matsuoka & Kaplan, 2008). It is important to research if trees especially assigned for their aesthetic preferences, in this case monumental trees

which are 'determining the street image', add a premium to property price. If this is the case, aesthetics is very likely to be an important motivation for adding a premium to property price.
In model 12 until 14, the monumental tree(s) (characteristics) are added into the regression. Note that the monumental tree dataset is a separate dataset than the regular public trees. This means that the monumental trees are not included into the dataset with the regular public trees. Analyzing models 12 and 13 shows that proximity of a monumental tree, within 100m to be specific, adds a higher coefficient than the number of monumental trees in a street. As both variables are positively significant, we can assume that Matsuoka & Kaplan (2008) are correct that nature, in this case trees, are appreciated for their aesthetic preferences.

FIGURE 9: Monumental Acacia.
Source: Municipality of Amsterdam (2019).

FIGURE 10: A row of monumental Planes at the Ceintuurbaan, older than 100 years. Source: Google Maps (2019).

Model 14 includes monumental trees per tree type and has the highest R-squared of 84,75%. The tree types included in this analysis are the 15 most common species in Amsterdam and are listed and pictured in the appendix on page 47. Results of monumental tree types indicate that the coefficient of Linden, Plane, Oak, Acacia, Horse Chestnut are positive and significantly increase property price. The Linden Plane and the Oak are trees which can get the eldest, up to 400 years old, they also have a large diameter. This is in line with the theory that people prefer older trees **(**Siriwardena et al., 2016). However, the Acacia and the Horse Chestnut also significantly increase property price and do not have outstanding tree characteristics. Tree species such as the Red Maple, the Tulip Popular, the Water Oak, the Black Oak and the Pin Oak, are broad leaved in the summer and lose their leaves in the wintertime. Due to the trees having less shade in the wintertime, homeowners do not have the higher heating costs (Pandit & Laband, 2010). As the Maple and the Popular show no significant premium on property price, this theory cannot be assumed to be correct for Amsterdam. The Plane tree has shown to have a significant influence on property price both within 100 metre and with monumental trees. It is possible that this is due to that the the Plane could be an excellent solution for stormwater regulation and water purification if managed properly because it catches the most rain, around 5m3 per year (Pearlmutter et al, 2017). It is important to note that all tree species, apart from the Plane, have a higher quantity with lower WOZ values. In general, there are more trees of lower property values. This influence the results and can lead to biased results.

4.5 Interactions between tree variables

Interactions between variables may be of interest to test the effect of multiple environmental characteristics on property price. Research in the Randstad area in the Netherlands showed that environmental characteristics do not exclude each other in the additional value to the property price. If a house has a garden, has a view over a lake and is adjacent to a green area, all three of those features will add value to the property price (Luttik, 2000).

TABLE 7: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 15 Trees per street & Apartment		Model 16 Trees per street & Garden		Model 17 Trees per street & balcony/r.	
	β	Std. Err.	β	Std. Err.	β	Std. Err.
Apartment [a]	-.025***	.003	-.056***	.003	-.056***	.003
Balcony or roof terrace [e]	.094***	.003	.094***	.003	.105***	.007
Garden [c]	.045***	.002	.026***	.002	.045***	.002
Ln. trees per street (per 100m)	.018***	.001	.004***	.0009	.007***	.0009
Ln. trees per street (per 100m) # apartment	-.013***	.002				
Ln. trees per street (per 100m) # garden			.008***	.001		
Ln. trees per street (per 100m) # balc. or rooft					-.005	.003
Constant	8.097***		9.051***		9.052***	
R-squared	8477		8473	.039	8472	.039

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1 **p<0.05. ***P<0.01.
Compared to: [a] House; [b] No balcony or roof terrace; [c] No garden.

Table 7 shows the interactions with trees per street and (environmental) housing characteristics. Results indicate that with the presence of a garden, the coefficient of the more trees per street is higher than without the presence of a garden. This finding supports the study of Luttik (2000) that environmental characteristics do not exclude each other. Interaction with trees per street and apartment have a coefficient closer to zero than the coefficient of the independent variable 'apartment'. This implies that the more trees in a street of an apartment, the smaller the negative value compared to a house.

Table 8 on the next page contains all tree variables. To prevent biased results due to high correlation, only one type of tree height and tree species variable are included in the model. As mentioned, monumental trees and 'regular' trees have no overlap and are originated from a different dataset. Therefore, monumental tree variables are included.

TABLE 8: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 18 All tree variables				
	β	Std. Err.			
Ln. Total liveable area (M2)	.747***	.003	Elm (Ulmus) dominant in street	-.010	.006
Built 1500-1905 [a]	.010	.035	Linden (Tilia) dominant in street	-.023***	.006
Built 1906-1944	-.017	.035	Maple (Acer) dominant in street	-.015	.006
Built 1945-1970	-.141***	.035	Ash (Fraxinus) dominant in street	-.018	.007
Built 1971-1990	-.085	.035	Plane (Platanus) dominant in street	-.006	.006
Built 1991-2000	-.007	.035	Popular (Populus) dominant in street	-.002	.008
Built after 2001	.074	.035	Oak (Quercus) dominant in street	-.017	.008
Neighbourhoods			Alder (Alnus) dominant in street	-.0007	.007
Apartment	-.056***	.003	Willow (Salix) dominant in street	-.006	.008
No. Rooms	.025***	.0009	Birch (Betula) dominant in street	-.020*	.007
No. Floors	.005***	.001	Cherry (Prunus) dominant in street	-.005	.007
Parking spot, cohort or garage [c]	.076***	.003	Hawthorn (Crataegus) dominant in street	.001	.007
Boiler or central heating [d]	.189***	.003	Hornbeam (Carpinus) dominant in street	-.006	.007
Airconditioning or solar panels [d]	.334***	.042	Acacia (Robinia) dominant in street	-.007	.007
Balcony or roof terrace [e]	.094***	.003	Horse chestnut (Aesculus) dominant in street	-.023*	.008
Garden [f]	.045***	.002			
Permanent ground lease [g]	-.030***	. 002	Total monumental trees per street	.001***	.0001
Varying ground lease [g]	-.148***	.002	Monumental tree is Elm (Ulmus)	.012	.006
			Monumental tree is Linden (Tilia)	.018***	.002
Ln. Distance to nearest tree (m)	.002*	.0007	Monumental tree is Maple (Acer)	.012	.005
Ln. Distance to nearest tram or metro [j]	.009***	.001	Monumental tree is Ash (Fraxinus)	.012	.012
Ln. Distance to nearest public sports field [k]	-.003**	.001	Monumental tree is Plane (Platanus)	.014***	.003
Ln. trees per street (per 100m)	.005***	.0009	Monumental tree is Popular (Populus)	.008	.006
Tree planted two years before property	.0005	.001	Monumental tree is Oak (Quercus)	.027***	.007
Total trees within 10m of property [i]	-.001	.0006	Monumental tree is Alder (Alnus)	-.090***	.016
Ln. total trees within 10-50m of property [i]	.003*	.001	Monumental tree is Willow (Salix)	.005	.007
Ln. total trees within 50-100m of property [i]	-.008***	.002	Monumental tree is Birch (Betula)	.014	.003
Most trees in street are 0 – 6 metres high	.009***	.002	Monumental tree is Cherry (Prunus)	-.100***	.020
Most trees in street are 6 – 9 metres high	.004	.002	Monumental tree is Hawthorn (Crataegus)	-.025	.035
Most trees in street are 9-12 metres high	.007**	.002	Monumental tree is Hornbeam (Carpinus)	.039	.017
Most trees in street are 12-15 metres high	.008***	.002	Monumental tree is Acacia (Robinia)	.048***	.013
Most trees in street are 15-18 metres high	.006**	.002	Monumental tree is Horse chestnut (Aesculus)	.020**	.006
Most trees in street are 18-25 metres high	.004	.002			
Most trees in street are 24 metres or higher	-.0004	.005			
Constant	9.095***	.040			
R-squared.	.8479				

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1 **p<0.05. ***P<0.01.
[a] compared to unknown or built before 1500. [b] See the results of the neighbourhoods in the appendix. House. dCoal or gas heating or [c] No parking spot, cohort or garage. compared to no trees. [e] No balcony or roof terrace. [f] No garden; [g] No ground lease.
N=100,503

The housing characteristics show stable results, the neighbourhood characteristics as well, only the distance to the nearest tree is now significant on a p<0.1 level, which was not significant in model 3. This means the further away the nearest tree, the higher the property price. The dominant tree height per street shows the same results as model 8, only trees between 12 to 15 metres high has a higher coefficient. Trees from 0 to 6-metre-high show the highest coefficient and is significant on a p<0.01

level. The majority of the dominant tree species per street has a negative coefficient. This implies that the variable is not stable and seems to be influenced by other independent variables. The result of the total monumental trees per street also remain unchanged. Of the monumental tree species, the Linden and Acacia have lower coefficients. The Plane, Oak and the Horse Chestnut have the same results. The coefficients of the Alder and Cherry are higher. Overall, the results of this model are stable.

As the access of public green can be dependent on income (Wolch et al., 2014), figures on page 63 in the appendix shows the relation between income and tree species and seems to be equally distributed. Around 80,000 trees are planted before 2010, only 20,000 after 2010. As the property sales year ranges from 2000 to 2017, there is chosen to take the WOZ values from 2010. For the next models, the dependent variable the log of the property sales price has been divided into three categories: 0-225,000 EUR, 225,000-500,000 EUR and higher than 500,000 EUR. The first two groups have a similar amount of observations: 47,216 and 45,568. The third group has significantly less observations: 7,543. This makes model 21 less reliable than models 19 and 20.

TABLE 10: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 19 Sales price 0-225,000 EUR				
	β	Std. Err.			
Apartment	-.091***	.004	Ash (Fraxinus) dominant in street	-.001	.008
No. Rooms	.030***	.001	Plane (Platanus) dominant in street	.004	.008
No. Floors	-.011***	.001	Popular (Populus) dominant in street	.026***	.010
Parking spot, cohort or garage [c]	.027***	.004	Oak (Quercus) dominant in street	.016	.009
Boiler or central heating [d]	.116***	.002	Alder (Alnus) dominant in street	.009	.008
Airconditioning or solar panels [d]	.196***	.042	Willow (Salix) dominant in street	.005	.010
Balcony or roof terrace [e]	.040***	.005	Birch (Betula) dominant in street	.0007	.008
Garden [f]	.028***	.001	Cherry (Prunus) dominant in street	.015	.008
Permanent ground lease [g]	-.022***	.001	Hawthorn (Crataegus) dominant in street	.012	.009
Varying ground lease [g]	-.102***	.002	Hornbeam (Carpinus) dominant in street	.011	.009
			Acacia (Robinia) dominant in street	.005	.008
Ln. Distance to nearest tree (m)	-.00002	.001	Horse chestnut (Aesculus) dominant in street	-.001	.009
Ln. Distance to nearest tram or metro [j]	.004**	.001			
Ln. Distance to nearest public sports field [k]	.0003	.001	Total monumental trees per street	.00009	.0002
Ln. trees per street (per 100m)	-.001	.001	Monumental tree is Elm (Ulmus)	.012	.009
Tree planted two years before property	-.003*	.001	Monumental tree is Linden (Tilia)	.020***	.003
Total trees within 10m of property [i]	-.0007	.0006	Monumental tree is Maple (Acer)	.012	.006
Ln. total trees within 10-50m of property [i]	.002	.001	Monumental tree is Ash (Fraxinus)	.008	.012
Ln. total trees within 50-100m of property [i]	-.004	.002	Monumental tree is Plane (Platanus)	.005	.007
Most trees in street are 0 – 6 metres high	.010***	.002	Monumental tree is Popular (Populus)	-.012	.008
Most trees in street are 6 – 9 metres high	.006**	.002	Monumental tree is Oak (Quercus)	.015	.008
Most trees in street are 9-12 metres high	.004	.002	Monumental tree is Alder (Alnus)	-.038**	.013
Most trees in street are 12-15 metres high	.009***	.002	Monumental tree is Willow (Salix)	.018	.009
Most trees in street are 15-18 metres high	.014***	.002	Monumental tree is Birch (Betula)	.017	.009
Most trees in street are 18-25 metres high	.006	.002	Monumental tree is Cherry (Prunus)	.009	.016
Most trees in street are 24 metres or higher	.006	.004	Monumental tree is Hawthorn (Crataegus)	.021	.038
			Monumental tree is Hornbeam (Carpinus)	-.009	.024
Elm (Ulmus) dominant in street	.002	.008	Monumental tree is Acacia (Robinia)	.012	.010
Linden (Tilia) dominant in street	.0003	.008	Monumental tree is Horse chestnut (Aesculus)	.017	.007
Maple (Acer) dominant in street	-.002	.008			

Constant	10.602***	.041
R-squared.	.6331	

Dependent variable is the log of sales price 0-225,000. N=47,216. *p<0.1 **p<0.05. ***P<0.01.

Model 19 shows that a tree planted two years before the sales of a property decreases the sales price on a p<0.5 level, which means that planting trees near dwellings of the lower category of property price is not beneficial before a property sale. The variable trees per street per 100 metre has a negative coefficient, though not significant. Tree heights 0-9 and 12-18 metres have positive coefficients. Theory suggested smaller trees increase property price of more expensive houses and larger trees decrease property price (Des Rosiers et al., 2002). The results of this research show that this is true for lower property prices. This might be the case because there is in general a higher quantity of trees near lower property prices, which makes the impact of trees larger. The Popular has a positive coefficient, significant on a p<0.01 level. The monumental tree Linden also has a positive coefficient, also on a p<0.01 level.

TABLE 11: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 20 Sales price 225,000-500,000 EUR				
	β	Std. Err.			
Apartment	-.032***	.004	Ash (Fraxinus) dominant in street	.011	.008
No. Rooms	.012***	.001	Plane (Platanus) dominant in street	.016	.008
No. Floors	-.001	.001	Popular (Populus) dominant in street	.003	.008
Parking spot, cohort or garage [c]	.054***	.002	Oak (Quercus) dominant in street	-.009	.008
Boiler or central heating [d]	.115***	.005	Alder (Alnus) dominant in street	.015	.008
Airconditioning or solar panels [d]	.198***	.052	Willow (Salix) dominant in street	.013	.008
Balcony or roof terrace [e]	.065***	.002	Birch (Betula) dominant in street	.005	.008
Garden [f]	.022***	.001	Cherry (Prunus) dominant in street	.014	.008
Permanent ground lease [g]	-.004***	.002	Hawthorn (Crataegus) dominant in street	.016	.008
Varying ground lease [g]	-.087***	.002	Hornbeam (Carpinus) dominant in street	.011	.008
			Acacia (Robinia) dominant in street	.013	.008
Ln. Distance to nearest tree (m)	.004***	.001	Horse chestnut (Aesculus) dominant in street	.018	.008
Ln. Distance to nearest tram or metro [j]	.010***	.001			
Ln. Distance to nearest public sports field [k]	-.003*	.0009	Total monumental trees per street	.0009***	.0001
Ln. trees per street (per 100m)	.003***	.001	Monumental tree is Elm (Ulmus)	.012	.009
Tree planted two years before property	-.001	.001	Monumental tree is Linden (Tilia)	.005	.003
Total trees within 10m of property [i]	-.00004	.008	Monumental tree is Maple (Acer)	.003	.006
Ln. total trees within 10-50m of property [i]	.001	.001	Monumental tree is Ash (Fraxinus)	.026	.012
Ln. total trees within 50-100m of property [i]	-.055	.002	Monumental tree is Plane (Platanus)	-.017***	.007
Most trees in street are 0 – 6 metres high	.002	.002	Monumental tree is Popular (Populus)	.010	.008
Most trees in street are 6 – 9 metres high	.005	.002	Monumental tree is Oak (Quercus)	-.025	.008
Most trees in street are 9-12 metres high	.004	.002	Monumental tree is Alder (Alnus)	-.017	.013
Most trees in street are 12-15 metres high	.005	.002	Monumental tree is Willow (Salix)	.012	.009
Most trees in street are 15-18 metres high	-.002	.002	Monumental tree is Birch (Betula)	-.043	.009
Most trees in street are 18-24 metres high	.0008	.002	Monumental tree is Cherry (Prunus)	-.179	.016
Most trees in street are 24 metres or higher	-.002	.002	Monumental tree is Hawthorn (Crataegus)	-.076	.038
			Monumental tree is Hornbeam (Carpinus)	.068	.024
Elm (Ulmus) dominant in street	.008	.008	Monumental tree is Acacia (Robinia)	.091***	.010
Linden (Tilia) dominant in street	.012	.008	Monumental tree is Horse chestnut (Aesculus)	-.008	.007
Maple (Acer) dominant in street	.004	.008			
Constant	10.2202***	.054			
R-squared.	.5561				

Log of sales price 225,000-500,000. N=45,568. *p<0.1 **p<0.05. ***P<0.01.

Model 20 shows that the number of trees per street per 100 metre is significant on a p<0.01 level as well as the distance to the nearest tree. No tree heights nor tree types have a significant result, the Plane tree has a negative coefficient. The only independent tree variables which have positive impact on property price are the monumental trees per street, which is significant on a p<0.01 level and the monumental Acacia which has a positive coefficient and is significant on a p<0.01 level.

Model 21 contains 380 observations that have a sales price of one million EUR or higher. In this model, having a balcony or roof terrace is not significant anymore, as well as the number of floors and air-conditioning or solar panels. Nor are any of the neighbourhood characteristics significant. The willow shows a significant positive influence on property price on a p<0.01 level. The total number of monumental trees per street is still significant, though only on a p<0.1 level.

TABLE 12: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 21 Sales price higher than 500,000 EUR				
	β	Std. Err.			
Apartment	-.033***	.007	Ash (Fraxinus) dominant in street	.008	.022
No. Rooms	.007***	.001	Plane (Platanus) dominant in street	-.007	.017
No. Floors	-.006	.003	Popular (Populus) dominant in street	-.041	.026
Parking spot, cohort or garage [c]	.027***	.006	Oak (Quercus) dominant in street	.040	.026
Boiler or central heating [d]	.113***	.013	Alder (Alnus) dominant in street	-.001	.022
Airconditioning or solar panels [d]	.228	.105	Willow (Salix) dominant in street	.122***	.029
Balcony or roof terrace [e]	.003	.004	Birch (Betula) dominant in street	-.040	.024
Garden [f]	.021***	.003	Cherry (Prunus) dominant in street	-.037	.019
Permanent ground lease [g]	-.009	.005	Hawthorn (Crataegus) dominant in street	-.010	.020
Varying ground lease [g]	-.069***	.006	Hornbeam (Carpinus) dominant in street	-.043	.021
			Acacia (Robinia) dominant in street	.0002	.018
Ln. Distance to nearest tree (m)	.005	.002	Horse chestnut (Aesculus) dominant in street	.033	.040
Ln. Distance to nearest tram or metro [j]	.007	.002			
Ln. Distance to nearest public sports field [k]	-.006	.002	Total monumental trees per street	.0007*	.009
Ln. trees per street (per 100m)	.003	.002	Monumental tree is Elm (Ulmus)	.0009	.019
Tree planted two years before property	-.005	.004	Monumental tree is Linden (Tilia)	.007	.006
Total trees within 10m of property [i]	.002	.002	Monumental tree is Maple (Acer)	.011	.012
Ln. total trees within 10-50m of property [i]	-.001	.003	Monumental tree is Ash (Fraxinus)	-.067	.066
Ln. total trees within 50-100m of property [i]	-.0009	.006	Monumental tree is Plane (Platanus)	-.003	.015
Most trees in street are 0 – 6 metres high	.007	.006	Monumental tree is Popular (Populus)	-.031	.015
Most trees in street are 6 – 9 metres high	.010	.006	Monumental tree is Oak (Quercus)	-.012	.029
Most trees in street are 9-12 metres high	.003	.006	Monumental tree is Alder (Alnus)	.066	.071
Most trees in street are 12-15 metres high	.007	.007	Monumental tree is Willow (Salix)	-.014	.021
Most trees in street are 15-18 metres high	.007	.006	Monumental tree is Birch (Betula)	-.014	.016
Most trees in street are 18-25 metres high	.016	.009	Monumental tree is Cherry (Prunus)	-.128	.038
Most trees in street are 24 metres or higher	-.007	.018	Monumental tree is Hawthorn (Crataegus)	.029	.024
			Monumental tree is Hornbeam (Carpinus)	.029	.010
Elm (Ulmus) dominant in street	.017	.016	Monumental tree is Acacia (Robinia)	-.128	.075
Linden (Tilia) dominant in street	-.026	.017	Monumental tree is Horse chestnut (Aesculus)	-.196	.153
Maple (Acer) dominant in street	-.028	.020			
Constant	10.54***	.104			
R-squared	.5649				

Dependent variable is the log of sales price higher than 500,000 EUR. N=7,543. *p<0.1 **p<0.05. ***P<0.01.

Model 21 also shows that the theory that smaller trees increase property price of more expensive houses and larger trees decrease property price (Des Rosiers et al., 2002), is not true for Amsterdam. The influence on monumental trees on property price is a stable influence and shows a premium on all the models where the variable is included. Trees tend to be more valuable when they are scarce rather than in areas with a large urban forest (Siriwardena et al., 2016). In tables 20 and 21, the variable monumental trees per street was positively significant. We still can assume that Matsuoka & Kaplan (2008) are correct that nature, in this case trees, are appreciated for their aesthetic preferences. Also, interaction tables and the tables with categorical dependent variables do not show strong results for tree species. In earlier sections in this chapter, Linden Plane and the Oak were significantly positive. As they are trees which can get the eldest, up to 400 years old, it seemed as that people prefer older trees **(**Siriwardena et al., 2016). In this subsection, solely the Linden has showed to be positively significant.

5. DISCUSSION

Green space is difficult to generalize (Panduro & Veie, 2013). However, there are some similarities between the findings of this study and the academic literature. Donovan & Butry (2010) found that the number of trees fronting the property and crown area within 30.5 meter of a house has a positive influence on the sales price. This research shows similarities as results indicate that a 10% increase of the number of trees within 10-50m of a property, increases property price by 0.05% on a $p<0.01$ level. Even though this result is statistically significant, it is not economically significant. This research has an additional result that shows that trees within 0-10 metre do not have an (positive) influence on property price. Earlier research found that trees close to/on private properties do not increase the value because they might block the view, drop leaves, take in too much space or take too much maintenance (Pandit et al., 2013). The results of this research might explain this finding. The property price decreases when the number of trees within 50-100 metre of a property increase, so people living in Amsterdam do not value tree coverage within 100m, while in the study of Sander et al. (2010) they do.
Results of tree characteristics within 100m of a property indicate that the Plane tree has a significant influence on property price. Model 9 shows that the Hawthorn significantly increases property price. Table 15 with tree types and their characteristics show that the Hawthorn tree is the smallest tree, can only get up to ca. 8 metres high and has a low shadow tolerance. Adding to that, model 19 showed that trees from 0 to 6 metres high have a significant premium to property price. Theory suggested smaller trees increase property price of more expensive houses and larger trees decrease property price (Des Rosiers et al., 2002). The results of this research show that this is true for lower property prices. This might be the case because there is in general a higher quantity of trees near lower property prices, which makes the impact of trees larger.

Almost all of the monumental trees have the function of determining the street image (Municipality of Amsterdam, 2019). Earlier research in residential neighbourhoods in The Netherlands showed that nature has the purpose for human interaction with nature and aesthetic preferences (Matsuoka & Kaplan, 2008). The influence on monumental trees on property price is a stable influence and shows a premium on all the models where the variable is included. Results of monumental trees types indicate that the coefficient of Linden, Plane, Oak, Acacia, Horse Chestnut are positive and significantly increase property price. The Linden Plane and the Oak are trees which can get the eldest, up to 400 years old, they also have a large diameter. This is in line with the theory that people prefer older trees and that aesthetics are important in the valuation of trees **(**Siriwardena et al., 2016). However, the Acacia and the Horse Chestnut also significantly increase property price and do not have outstanding tree characteristics. Tree species such as the Red Maple, the Tulip Popular, the Water Oak, the Black Oak and the Pin Oak, are broad leaved in the summer and lose their leaves in the wintertime. Due to the trees having less shade in the wintertime, homeowners do not have the higher heating costs (Pandit & Laband, 2010). As the Maple and the Popular show no significant premium on property price, this theory cannot be assumed to be correct for Amsterdam. The Plane has shown to have a significant influence on property price both within 100 metre and with monumental trees. It is possible that this is due to that the the Plane could be an excellent solution for stormwater regulation and water purification if managed properly because it catches the most rain, around 5m3 per year (Pearlmutter et al, 2017). It is important to note that all tree species, apart from the Plane, have a higher quantity with lower WOZ values. In general, there are more trees of lower property values. This influence the results and can lead to biased results. Also, interaction tables and the tables with categorical dependent variables do not show strong results for tree species.
Some tree variables have shown (significant) negative coefficients, such as the monumental Cherry tree. As Zhang & Dong, (2018) mentioned, public street greenery can have several functions: recreational functions, ecological functions, can reduce noise pollution or purity the air or solely 'beautify' the streetscape. Trees that have regressed a negative relationship with property price, can be negative because they simply do not 'beautify' the streetscape or because they have other negative externalities, such as they block views, drop leaves and can damage pavements (Donovan & Butry, 2010). However, this does not mean that trees that have regressed a negative relationship with property price do not have essential characteristics like recreational functions, ecological functions, can reduce noise pollution or purity the air.

Research in the Randstad area in the Netherlands showed that environmental characteristics do not exclude each other in the additional value to the property price. If a house has a garden, has a view over a lake and is adjacent to a green area, all three of those features will add value to the property price (Luttik, 2000). The interaction with a garden shows that when a property has a garden, the more trees per street the higher the property price. The coefficient of this interaction is higher than the coefficient of solely trees per street. Interaction with trees per street and apartment. the negative coefficient of the interaction is closer to zero than the coefficient of the independent variable 'apartment'. The interaction with trees per street per 100 metre and a garden shows that when a property has a garden, the more trees per street the higher the property price. The coefficient of this interaction is higher than the coefficient of solely trees per street. Thus, this finding supports the study of Luttik (2000) that environmental characteristics do not exclude each other. Results of model 11 show that if a tree is planted 2 years before a property sale, it significantly increases the property price. This implies that planting extra trees adds a premium to the sales price of a property and that is therefore helpful to plant more trees in the city. However, this is not shown to be true for property prices of 0-225,000.

Model 8 shows the same results as Model 5, Trees 15-18 are significant on an $p<0.01$ level, but with a lower coefficient. Trees 15-18 have shown to have a positive influence on property price and should therefore be encouraged to plant. However, streets with high trees and especially with a large canopy cover can also have negative effects. A high tree canopy cover can also lead to a higher surface temperature because the heat cannot escape (Keuken & Van der Valk, 2010). Compared to a period without leaves, periods with leaves reduce the ability of 'fresh' air to come in the street-canyon, which consequently leads to leaves increasing traffic emissions and this increase levels of air pollution. This shows again that the planting of new trees is a complex matter and benefits are not easy and straight forward.

Overall, the effect in Amsterdam seems to be less pronounced than in most studies. The economic value of trees on property price is very low. Perhaps due to different function of trees and urban green compared to American/Australian studies. To be sure, additional qualitative studies or comparative case studies of trees within the USA or Australia and The Netherlands are needed. It is important to note that there is a weakness to this study of the coincidence of results, especially the tree type data seemed not to be stable. Because the relation between trees and property price is not a strong one, it is valuable to do additional research on the influence of trees and the negative effects of canopy cover, so that is clearer which tree species the Municipality of Amsterdam should plant. Also, the role of urban trees is tied with both natural and man-made systems (Pearlmutter et al, 2017). When looking at the picture of the Hawthorn trees in the Spinozastraat in Amsterdam, I can see why it would put a price premium of the property price. Still, weakness of aesthetics that is stays subjective and the opinions of home buyers are not taken into account. This would be a good study in the future, of specific tree types and people's opinions included. Because the importance of nature in cities needs to be better communicated so that city planners and landscape designers will understand the (economic) value again (Matsuoka & Kaplan, 2008).

6. CONCLUSION

This thesis researched the questions: *In what way influence public street trees property prices in Amsterdam?* This research shows no economically significant results. It does show statistically significant results: a 10% increase of trees per street (per 100m) has a 0.03% to 0.05% premium on property price. Trees within 10-50 metre of a property show a positive influence ranging from 0.02% to 0.05%, trees up to 10 metres from a property show negative influence. Of street trees, the Hawthorn tree shows a positive influence on property price, which the smallest tree of all 15 species. Trees from 0-6 metre have also shown to have a premium. Furthermore, the presence of monumental trees in a street shows a stable positive influence on property price as well as monumental trees Linden, Plane, Oak, Acacia and Horse Chestnut also show a positive influence on property price, which shows the importance of aesthetics when it comes to trees. Also, several environmental characteristics seem to increase the positive influence on property price, such as the presence of a garden and trees in the street. Overall, green space is shown to be still difficult to generalize, as the results of the influence of trees do not have exactly the same results as previous studies (Panduro & Veie, 2013). Some coefficients are even negative in this research, such as the number of trees within 0-10 metre and 50-100 metre of a property and there are no economic significanct results in this study.

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APPENDIX A: TABLES WITH ALL RESULTS

TABLE 2: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 1 Base model 1		Model 2 Base model 2		Model 3 Distance to nearest tree	
	β	Std. Err.	β	Std. Err.	β	Std. Err.
Ln. Total liveable area (M2)	.751***	.003	.751***	.003	.752***	0.003
Built 1500-1905 [a]	.014	.035	.015	.035	.015	.035
Built 1906-1944	-.014	.035	-.013	.035	-.013	.035
Built 1945-1970	-.140***	.035	-.140***	.035	-.140***	.035
Built 1971-1990	-.086	.035	-.086	.035	-.086	.035
Built 1991-2000	-.007	.035	-.005	.035	-.003	.035
Built after 2001	.074	.035	.074	.035	.074	.035
Neighbourhoods [b]						
Apartment [c]	-.057***	.003	-.056***	.003	-.056***	.003
No. Rooms	.025***	.0009	.025***	.0009	.025***	.0009
No. Floors	.005***	.001	.005***	.001	.005***	.001
Parking spot, cohort or garage [d]	.077***	.003	.076***	.003	.076***	.003
Boiler or central heating [e]	.189***	.003	.189***	.003	.189***	.003
Airconditioning or solar panels [e]	.336***	.042	.337***	.042	.336***	.042
Balcony or roof terrace [f]	.094***	.003	.094***	.003	.094***	.003
Garden [g]	.045***	.002	.045***	.002	.045***	.002
Permanent ground lease [h]	-.031***	.002	-.030***	.002	-.030***	. 002
Varying ground lease [h]	-.149***	.002	-.148***	.002	-.148***	.002
Ln. Distance to nearest public tree (m)					.0002	.0007
Ln. Distance to nearest tram or metro (m)			.009***	.001	.009***	.001
Ln. Distance to nearest public sports field (m)			-.003**	.001	-.003**	.001
Constant	9.110***	.038	9.065***	.044	9.070***	.044
R-squared	0.8470		0.8471		.8471	

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1 **p<0.05. ***P<0.01.

[a]Compared to unknown or built before 1500; [b] The results of the neighbourhoods are not listed due to the high number of neighbourhoods, all the neighbourhoods are listed in the appendix; [c]Compared to a house; [d]Compared to no parking spot, cohort or garage; [e]Coal or gas heating; [f]Compared to no balcony or roof terrace; [g] Compared to no garden; [h]Compared to no ground lease; [i]

TABLE 3: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 4 Total trees within 0-100m		Model 5 Dominant tree height within 100m		Model 6 Tree species before property	
	β	Std. Err.	β	Std. Err.	β	Std. Err.
Ln. Total liveable area (M2)	.750***	.003	.751***	.003	.751***	.003
Built 1500-1905 [a]	.014	.035	.016	.035	.016	.035
Built 1906-1944 [a]	-.014	.035	-.011	.035	-.011	.035
Built 1945-1970 [a]	-.139***	.035	-.137***	.035	-.137***	.035
Built 1971-1990 [a]	-.085	.035	-.083	.035	-.083	.035
Built 1991-2000 [a]	-.005	.035	-.003	.035	-.003	.035
Built after 2001 [a]	.074	.035	.076	.035	.076	.035
Neighbourhoods [b]						
Apartment [c]	-.056***	.003	-.056***	.003	-.056***	.003
No. Rooms	.025***	.0009	.025***	.0009	.025***	.0009
No. Floors	.005***	.001	.005***	.001	.005***	.001
Parking spot, cohort or garage [d]	.076***	.003	.076***	.003	.076***	.003
Boiler or central heating [e]	.189***	.003	.189***	.003	.189***	.003
Airconditioning or solar panels [e]	.337***	.042	.337***	.042	.337***	.042
Balcony or roof terrace [f]	.093***	.003	.093***	.003	.093***	.003
Garden [g]	.045***	.002	.045***	.002	.045***	.002
Permanent ground lease [h]	-.030***	.002	-.030***	.002	-.030***	.002
Varying ground lease [h]	-.148***	.002	-.148***	.002	-.148***	.002
Total trees within 10m of property [i]	-.001	.0004				
Ln. total trees within 10-50m of property [i]	.005***	.001				
Ln. total trees within 50-100m of property [i]	-.006**	.002				
Most trees within 100m are 6–9m high [j]			-.0004	.003		
Most trees within 100m are 9-12m high			.001	.003		
Most trees within 100m are 12-15m high			.0003	.003		
Most trees within 100m are 15-18m high			.005*	.003		
Most trees within 100m are 18-24m high			.0009	.003		
Most trees within 100m are 24m or higher			.002	.005		
Elm (Ulmus) before property					.0003	.002
Linden (Tilia) before property					.0005	.002
Maple (Acer) before property					-.001	.002
Ash (Fraxinus) before property					.0003	.003
Plane (Platanus) before property					.008*	.002
Popular (Populus) before property					-.010	.004
Oak (Quercus) before property					.001	.004
Alder (Alnus) before property					.006	.003
Willow (Salix) before property					.010	.004
Birch (Betula) before property					.007	.003
Cherry (Prunus) before property					.002	.003
Hawthorn (Crataegus) before property					-.0006	.004
Hornbeam (Carpinus) before property					.0008	.003
Acacia (Robinia) before property					.001	.003
Horse chestnut (Aesculus) before property					.002	.003
Ln. Distance to nearest tram or metro (m)	.008***	.001	.008***	.001	.009***	.001
Ln. Distance to nearest public sports field (m)	-.003***	.001	-.003***	.001	-.003**	.001
Constant	9.101***	.040	9.075***	.044	9.065***	.044
R-squared	.8466		.8467		.8472	

TABLE 4: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 7 Trees per street		Model 8 Tree height		Model 9 Tree species	
	β	Std. Err.	β	Std. Err.	β	Std. Err.
Ln. Total liveable area (M2)	.751***	0003	.752***	.003	.751***	.003
Built 1500-1905 [a]	.015	.035	.015	.035	.014	.035
Built 1906-1944 [a]	-.013	.035	-.013	.035	-.014	.035
Built 1945-1970 [a]	-.138***	.035	-.138***	.035	-.139***	.035
Built 1971-1990 [a]	-.085	.035	-.085	.035	-.085	.035
Built 1991-2000 [a]	-.003	.035	-.003	.035	-.005	.035
Built after 2001 [a]	.076	.035	.076	.035	.074	.035
Neighbourhoods [b]						
Apartment [c]	-.056***	.003	-.056***	.003	-.056***	.003
No. Rooms	.025***	.0009	.025***	.0009	.025***	.0009
No. Floors	.005***	.001	.005***	.001	.005***	.001
Parking spot, cohort or garage [d]	.076***	.003	.076***	.003	.076***	.003
Boiler or central heating [e]	.189***	.003	.189***	.003	.189***	.003
Airconditioning or solar panels [e]	.336***	.042	.336***	.042	.337***	.042
Balcony or roof terrace [f]	.094***	.003	.094***	.003	.093***	.003
Garden [g]	.045***	.002	.045***	.002	.045***	.002
Permanent ground lease [h]	-.030***	. 002	-.030***	. 002	-.030***	.002
Varying ground lease [h]	-.148***	.002	-.148***	.002	-.148***	.002
Ln. trees per street (per 100m)	.007***	.0009				
Tree is 0 – 6 metres high			.00008	.00003		
Tree is 6 – 9 metres high			-.00002	.00003		
Tree is 9-12 metres high			.00005	.00004		
Tree is 12-15 metres high			.00001	.00002		
Tree is 15-18 metres high			.0001***	.00004		
Tree is 18-24 metres high			-.00009	.00003		
Tree is 24 metres or higher			.0001	.00009		
Elm (Ulmus) dominant in street					.008	.006
Linden (Tilia) dominant in street					-.003	.006
Maple (Acer) dominant in street					.0007	.006
Ash (Fraxinus) dominant in street					.001	.006
Plane (Platanus) dominant in street					.013	.006
Popular (Populus) dominant in street					.020	.008
Oak (Quercus) dominant in street					-0.13	.007
Alder (Alnus) dominant in street					.013	.007
Willow (Salix) dominant in street					.009	.008
Birch (Betula) dominant in street					-.002	.007
Cherry (Prunus) dominant in street					.015	.006
Hawthorn (Crataegus) dominant in street					.020*	.007
Hornbeam (Carpinus) dominant in street					.009	.007
Acacia (Robinia) dominant in street					.007	.006
Horse chestnut (Aesculus) dominant in street					-.005	.008
Ln. Distance to nearest tram or metro	.009***	.001	.009***	.001	.009***	.001
Ln. Distance to nearest public sports field	-.003**	.001	-.003**	.001	-.003**	.001
Constant	9.052***	.044	9.065***	.044	9.056***	.044
R-squared	0.8473		.8474		.8473	

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1 **p<0.05. ***P<0.01.
The independent variables are compared to: [a] unknown or built before 1500; [c] a house; [d] no parking spot, cohort or garage; [e] Coal or gas heating; [f] no balcony or roof terrace; [g] no garden; [h] No ground lease. [b] Results are not taking into the regression due to high quantity.

TABLE 5: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 10 Planted 2yrs before sale		Model 11 Dominant tree height	
	β	Std. Err.	β	Std. Err.
Ln. Total liveable area (M2)	.751***	0.003	.751***	0.003
Built 1500-1905 [a]	.015	.035	.015	.035
Built 1906-1944 [a]	-.012	.035	-.012	.035
Built 1945-1970 [a]	-.138***	.035	-.138***	.035
Built 1971-1990 [a]	-.085	.035	-.085	.035
Built 1991-2000 [a]	-.003	.035	-.003	.035
Built after 2001 [a]	.076	.035	.076	.035
Neighbourhoods [b]				
Apartment [c]	-.056***	.003	-.056***	.003
No. Rooms	.025***	.0009	.025***	.0009
No. Floors	.005***	.001	.005***	.001
Parking spot, cohort or garage [d]	.076***	.003	.076***	.003
Boiler or central heating [e]	.189***	.003	.189***	.003
Airconditioning or solar panels [e]	.336***	.042	.336***	.042
Balcony or roof terrace [f]	.094***	.003	.094***	.003
Garden [g]	.045***	.002	.045***	.002
Permanent ground lease [h]	-.030***	. 002	-.030***	. 002
Varying ground lease [h]	-.148***	.002	-.148***	.002
Tree planted two years before property	.006***	.001		
Most trees in street are 0-6m high			.009***	.001
Most trees in street are 6–9m high			.003	.002
Most trees in street are 9-12m high			.006**	.001
Most trees in street are 12-15m high			.007**	.002
Most trees in street are 15-18m high			.007**	.002
Most trees in street are 18-24m high			.005	.003
Most trees in street are 24m or higher			.001	.009
Ln. Distance to nearest tram or metro [j]				
Ln. Distance to nearest public sports field [k]				
Constant	9.028***	.0444	9.085***	.0385
R-squared	.8474		.8474	

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1 **p<0.05. ***P<0.01.
The independent variables are compared to: [a]unknown or built before 1500; [c] a house; [d] no parking spot, cohort or garage; [e] Coal or gas heating; [f] no balcony or roof terrace; [g] no garden; [h] No ground lease. Results are not taking into the regression due to high quantity.

TABLE 6: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 12 Tree within 100m		Model 13 Total trees per street		Model 14 Tree species	
	β	Std. Err.	β	Std. Err.	β	Std. Err.
Ln. Total liveable area (M2)	.750***	.003	.750***	.003	.750***	0.003
Built 1500-1905 [a]	.015	.035	.015	.035	.017	.035
Built 1906-1944	-.013	.035	-.013	.035	-.010	.035
Built 1945-1970	-.136***	.035	-.136***	.035	-.134***	.035
Built 1971-1990	-.085	.035	-.085	.035	-.080	.035
Built 1991-2000	-.003	.035	-.003	.035	-.001	.035
Built after 2001	.076	.035	.076	.035	.078	.035
Neighbourhoods						
Apartment [b]	-.056***	.003	-.056***	.003	-.056***	.003
No. Rooms	.025***	.0009	.025***	.0009	.025***	.0009
No. Floors	.005***	.001	.005***	.001	.005***	.001
Parking spot, cohort or garage [c]	.076***	.003	.076***	.003	.076***	.003
Boiler or central heating [d]	.189***	.003	.189***	.003	.189***	.003
Airconditioning or solar panels [d]	.336***	.042	.336***	.042	.336***	.042
Balcony or roof terrace [e]	.094***	.003	.094***	.003	.094***	.003
Garden [f]	.045***	.002	.045***	.002	.045***	.002
Permanent ground lease [g]	-.030***	. 002	-.030***	. 002	-.029***	. 002
Varying ground lease [g]	-.148***	.002	-.148***	.002	-.147***	.002
Monumental tree in within 100m	.020***	.001				
Total monumental trees per street			.0016***	.0001		
Monumental tree is Elm (Ulmus)					.012	.006
Monumental tree is Linden (Tilia)					.029***	.002
Monumental tree is Maple (Acer)					.012	.005
Monumental tree is Ash (Fraxinus)					.012	.012
Monumental tree is Plane (Platanus)					.014***	.003
Monumental tree is Popular (Populus)					.008	.006
Monumental tree is Oak (Quercus)					.027***	.007
Monumental tree is Alder (Alnus)					-.080***	.016
Monumental tree is Willow (Salix)					.005	.007
Monumental tree is Birch (Betula)					.014	.003
Monumental tree is Cherry (Prunus)					-.085***	.020
Monumental tree is Hawthorn (Crataegus)					-.025	.035
Monumental tree is Hornbeam (Carpinus)					.039	.017
Monumental tree is Acacia (Robinia)					.058***	.013
Monumental tree is Horse chestnut (Aesculus)					.020**	.006
Ln. Distance to nearest tram or metro [j]	.009***	.001	.009***	.001	.009***	.001
Ln. Distance to nearest public sports field [k]	-.003**	.001	-.003**	.001	-.002*	.001
Constant	9.076***	.044	9.067***	.044	9.066***	.044
R-squared	.8474		.8473		.8475	

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1, **p<0.05, ***P<0.01.

The independent variables are compared to: [a]Unknown or built before 1500; [c] a house; [d] no parking spot, cohort or garage; [e] Coal or gas heating; [f] no balcony or roof terrace; [g] no garden; [h]no ground lease;

TABLE 7: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 19 Trees per street & Apartment		Model 20 Trees per street & Garden		Model 21 Trees per street & balcony/r.	
	β	Std. Err.	β	Std. Err.	β	Std. Err.
Ln. Total liveable area (M2)	.751***	0.003	.751***	0.003	.751***	0.003
Built 1500-1905 [a]	.015	.035	.015	.035	.015	.035
Built 1906-1944	-.012	.035	-.012	.035	-.012	.035
Built 1945-1970	-.138***	.035	-.138***	.035	-.138***	.035
Built 1971-1990	-.085	.035	-.085	.035	-.085	.035
Built 1991-2000	-.003	.035	-.003	.035	-.003	.035
Built after 2001	.076	.035	.076	.035	.076	.035
Neighbourhoods						
Apartment [b]	-.025***	.003	-.056***	.003	-.056***	.003
No. Rooms	.025***	.0009	.025***	.0009	.025***	.0009
No. Floors	.005***	.001	.005***	.001	.005***	.001
Parking spot, cohort or garage [c]	.076***	.003	.076***	.003	.076***	.003
Boiler or central heating [d]	.189***	.003	.189***	.003	.189***	.003
Airconditioning or solar panels [d]	.336***	.042	.336***	.042	.336***	.042
Balcony or roof terrace [e]	.094***	.003	.094***	.003	.105***	.007
Garden [f]	.045***	.002	.026***	.002	.045***	.002
Permanent ground lease [g]	-.030***	. 002	-.030***	. 002	-.030***	. 002
Varying ground lease [g]	-.148***	.002	-.148***	.002	-.148***	.002
Ln. trees per street (per 100m)	.018***	.001	.004***	.0009	.007***	.0009
Ln. trees per street (per 100m) # apartment	-.013***	.002				
Ln. trees per street (per 100m) # garden			.008***	.001		
Ln. trees per street (per 100m) # balc. or rooft					-.005	.003
Ln. Distance to nearest tram or metro [j]	.008***	.001	.009***	.001	.009***	.001
Ln. Distance to nearest public sports field [k]	-.003**	.001	-.003**	.001	-.003**	.001
Constant	8.097***		9.051***		9.052***	
R-squared	8477		8473	.039	8472	.039

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1 **p<0.05. ***P<0.01.
[a] compared to unknown or built before 1500. [b] See the results of the neighbourhoods in the appendix. House. dCoal or gas heating or [c] No parking spot, cohort or garage. compared to no trees. [e] No balcony or roof terrace. [f] No garden; [g] No ground lease.

TABLE 8: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 22 All tree variables				
	β	Std. Err.			
Ln. Total liveable area (M2)	.747***	.003	Elm (Ulmus) dominant in street	-.010	.006
Built 1500-1905 [a]	.010	.035	Linden (Tilia) dominant in street	-.023***	.006
Built 1906-1944	-.017	.035	Maple (Acer) dominant in street	-.015	.006
Built 1945-1970	-.141***	.035	Ash (Fraxinus) dominant in street	-.018	.007
Built 1971-1990	-.085	.035	Plane (Platanus) dominant in street	-.006	.006
Built 1991-2000	-.007	.035	Popular (Populus) dominant in street	-.002	.008
Built after 2001	.074	.035	Oak (Quercus) dominant in street	-.017	.008
Neighbourhoods			Alder (Alnus) dominant in street	-.0007	.007
Apartment	-.056***	.003	Willow (Salix) dominant in street	-.006	.008
No. Rooms	.025***	.0009	Birch (Betula) dominant in street	-.020*	.007
No. Floors	.005***	.001	Cherry (Prunus) dominant in street	-.005	.007
Parking spot, cohort or garage [c]	.076***	.003	Hawthorn (Crataegus) dominant in street	.001	.007
Boiler or central heating [d]	.189***	.003	Hornbeam (Carpinus) dominant in street	-.006	.007
Airconditioning or solar panels [d]	.334***	.042	Acacia (Robinia) dominant in street	-.007	.007
Balcony or roof terrace [e]	.094***	.003	Horse chestnut (Aesculus) dominant in street	-.023*	.008
Garden [f]	.045***	.002			
Permanent ground lease [g]	-.030***	. 002	Total monumental trees per street	.001***	.0001
Varying ground lease [g]	-.148***	.002	Monumental tree is Elm (Ulmus)	.012	.006
			Monumental tree is Linden (Tilia)	.018***	.002
Ln. Distance to nearest tree (m)	.002*	.0007	Monumental tree is Maple (Acer)	.012	.005
Ln. Distance to nearest tram or metro [j]	.009***	.001	Monumental tree is Ash (Fraxinus)	.012	.012
Ln. Distance to nearest public sports field [k]	-.003**	.001	Monumental tree is Plane (Platanus)	.014***	.003
Ln. trees per street (per 100m)	.005***	.0009	Monumental tree is Popular (Populus)	.008	.006
Tree planted two years before property	.0005	.001	Monumental tree is Oak (Quercus)	.027***	.007
Total trees within 10m of property [i]	-.001	.0006	Monumental tree is Alder (Alnus)	-.090***	.016
Ln. total trees within 10-50m of property [i]	.003*	.001	Monumental tree is Willow (Salix)	.005	.007
Ln. total trees within 50-100m of property [i]	-.008***	.002	Monumental tree is Birch (Betula)	.014	.003
Most trees in street are 0 – 6 metres high	.009***	.002	Monumental tree is Cherry (Prunus)	-.100***	.020
Most trees in street are 6 – 9 metres high	.004	.002	Monumental tree is Hawthorn (Crataegus)	-.025	.035
Most trees in street are 9-12 metres high	.007**	.002	Monumental tree is Hornbeam (Carpinus)	.039	.017
Most trees in street are 12-15 metres high	.008***	.002	Monumental tree is Acacia (Robinia)	.048***	.013
Most trees in street are 15-18 metres high	.006**	.002	Monumental tree is Horse chestnut (Aesculus)	.020**	.006
Most trees in street are 18-25 metres high	.004	.002			
Most trees in street are 24 metres or higher	-.0004	.005			
Constant	9.095***	.040			
R-squared.	.8479				

N=100,503. Note: Dependent variable is log of transaction price. Significance levels: *p<0.1 **p<0.05. ***P<0.01.
[a] compared to unknown or built before 1500. [b] See the results of the neighbourhoods in the appendix. House. dCoal or gas heating or [c] No parking spot, cohort or garage. compared to no trees. [e] No balcony or roof terrace. [f] No garden; [g] No ground lease.
N=100,503

TABLE 9: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 23 Sales price 0-225.000 EUR				
	β	Std. Err.			
Ln. Total liveable area (M2)	.373***	.003	Elm (Ulmus) dominant in street	.002	.008
Built 1500-1905 [a]	.018	.035	Linden (Tilia) dominant in street	.0003	.008
Built 1906-1944	.015	.035	Maple (Acer) dominant in street	-.002	.008
Built 1945-1970	-.061	.035	Ash (Fraxinus) dominant in street	-.001	.008
Built 1971-1990	-.031	.035	Plane (Platanus) dominant in street	.004	.008
Built 1991-2000	.051	.035	Popular (Populus) dominant in street	.026***	.010
Built after 2001	.106**	.035	Oak (Quercus) dominant in street	.016	.009
Neighbourhoods			Alder (Alnus) dominant in street	.009	.008
Apartment	-.091***	.004	Willow (Salix) dominant in street	.005	.010
No. Rooms	.030***	.001	Birch (Betula) dominant in street	.0007	.008
No. Floors	-.011***	.001	Cherry (Prunus) dominant in street	.015	.008
Parking spot, cohort or garage [c]	.027***	.004	Hawthorn (Crataegus) dominant in street	.012	.009
Boiler or central heating [d]	.116***	.002	Hornbeam (Carpinus) dominant in street	.011	.009
Airconditioning or solar panels [d]	.196***	.042	Acacia (Robinia) dominant in street	.005	.008
Balcony or roof terrace [e]	.040***	.005	Horse chestnut (Aesculus) dominant in street	-.001	.009
Garden [f]	.028***	.001			
Permanent ground lease [g]	-.022***	.001	Total monumental trees per street	.00009	.0002
Varying ground lease [g]	-.102***	.002	Monumental tree is Elm (Ulmus)	.012	.009
			Monumental tree is Linden (Tilia)	.020***	.003
Ln. Distance to nearest tree (m)	-.00002	.001	Monumental tree is Maple (Acer)	.012	.006
Ln. Distance to nearest tram or metro [j]	.004**	.001	Monumental tree is Ash (Fraxinus)	.008	.012
Ln. Distance to nearest public sports field [k]	.0003	.001	Monumental tree is Plane (Platanus)	.005	.007
Ln. trees per street (per 100m)	-.001	.001	Monumental tree is Popular (Populus)	-.012	.008
Tree planted two years before property	-.003*	.001	Monumental tree is Oak (Quercus)	.015	.008
Total trees within 10m of property [i]	-.0007	.0006	Monumental tree is Alder (Alnus)	-.038**	.013
Ln. total trees within 10-50m of property [i]	.002	.001	Monumental tree is Willow (Salix)	.018	.009
Ln. total trees within 50-100m of property [i]	-.004	.002	Monumental tree is Birch (Betula)	.017	.009
Most trees in street are 0 – 6 metres high	.010***	.002	Monumental tree is Cherry (Prunus)	.009	.016
Most trees in street are 6 – 9 metres high	.006**	.002	Monumental tree is Hawthorn (Crataegus)	.021	.038
Most trees in street are 9-12 metres high	.004	.002	Monumental tree is Hornbeam (Carpinus)	-.009	.024
Most trees in street are 12-15 metres high	.009***	.002	Monumental tree is Acacia (Robinia)	.012	.010
Most trees in street are 15-18 metres high	.014***	.002	Monumental tree is Horse chestnut (Aesculus)	.017	.007
Most trees in street are 18-25 metres high	.006	.002			
Most trees in street are 24 metres or higher	.006	.004			
Constant	10.602***	.041			
R-squared.	.6331				

Dependent variable is the log of sales price 0-225.000. N=47,216. *p<0.1 **p<0.05. ***P<0.01.

TABLE 10: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 24 Sales price 225.000-500.000 EUR				
	β	Std. Err.			
Ln. Total liveable area (M2)	.515***	.003	Elm (Ulmus) dominant in street	.008	.008
Built 1500-1905 [a]	.018	.049	Linden (Tilia) dominant in street	.012	.008
Built 1906-1944	.0007	.049	Maple (Acer) dominant in street	.004	.008
Built 1945-1970	-.052	.049	Ash (Fraxinus) dominant in street	.011	.008
Built 1971-1990	-.051	.049	Plane (Platanus) dominant in street	.016	.008
Built 1991-2000	-.014	.049	Popular (Populus) dominant in street	.003	.008
Built after 2001	.038	.049	Oak (Quercus) dominant in street	-.009	.008
Neighbourhoods			Alder (Alnus) dominant in street	.015	.008
Apartment	-.032***	.004	Willow (Salix) dominant in street	.013	.008
No. Rooms	.012***	.001	Birch (Betula) dominant in street	.005	.008
No. Floors	-.001	.001	Cherry (Prunus) dominant in street	.014	.008
Parking spot, cohort or garage [c]	.054***	.002	Hawthorn (Crataegus) dominant in street	.016	.008
Boiler or central heating [d]	.115***	.005	Hornbeam (Carpinus) dominant in street	.011	.008
Airconditioning or solar panels [d]	.198***	.052	Acacia (Robinia) dominant in street	.013	.008
Balcony or roof terrace [e]	.065***	.002	Horse chestnut (Aesculus) dominant in street	.018	.008
Garden [f]	.022***	.001			
Permanent ground lease [g]	-.004***	.002	Total monumental trees per street	.0009***	.0001
Varying ground lease [g]	-.087***	.002	Monumental tree is Elm (Ulmus)	.012	.009
			Monumental tree is Linden (Tilia)	.005	.003
Ln. Distance to nearest tree (m)	.004***	.001	Monumental tree is Maple (Acer)	.003	.006
Ln. Distance to nearest tram or metro [j]	.010***	.001	Monumental tree is Ash (Fraxinus)	.026	.012
Ln. Distance to nearest public sports field [k]	-.003*	.0009	Monumental tree is Plane (Platanus)	-.017***	.007
Ln. trees per street (per 100m)	.003***	.001	Monumental tree is Popular (Populus)	.010	.008
Tree planted two years before property	-.001	.001	Monumental tree is Oak (Quercus)	-.025	.008
Total trees within 10m of property [i]	-.00004	.008	Monumental tree is Alder (Alnus)	-.017	.013
Ln. total trees within 10-50m of property [i]	.001	.001	Monumental tree is Willow (Salix)	.012	.009
Ln. total trees within 50-100m of property [i]	-.055	.002	Monumental tree is Birch (Betula)	-.043	.009
Most trees in street are 0 – 6 metres high	.002	.002	Monumental tree is Cherry (Prunus)	-.179	.016
Most trees in street are 6 – 9 metres high	.005	.002	Monumental tree is Hawthorn (Crataegus)	-.076	.038
Most trees in street are 9-12 metres high	.004	.002	Monumental tree is Hornbeam (Carpinus)	.068	.024
Most trees in street are 12-15 metres high	.005	.002	Monumental tree is Acacia (Robinia)	.091***	.010
Most trees in street are 15-18 metres high	-.002	.002	Monumental tree is Horse chestnut (Aesculus)	-.008	.007
Most trees in street are 18-24 metres high	.0008	.002			
Most trees in street are 24 metres or higher	-.002	.002			
Constant	10.2202***	.054			
R-squared.	.5561				

Log of sales price 225.000-500.000. N=45,568. *p<0.1 **p<0.05. ***P<0.01.

TABLE 11: ESTIMATION RESULTS FOR PRICE MODELS, OLS ESTIMATES

	Model 25 Sales price higher than 500.000 EUR				
	β	Std. Err.			
Ln. Total liveable area (M2)	.559***	.010	Elm (Ulmus) dominant in street	.017	.016
Built 1500-1905 [a]	-.023	.073	Linden (Tilia) dominant in street	-.026	.017
Built 1906-1944	-.045	.073	Maple (Acer) dominant in street	-.028	.020
Built 1945-1970	-.071	.073	Ash (Fraxinus) dominant in street	.008	.022
Built 1971-1990	-.061	.073	Plane (Platanus) dominant in street	-.007	.017
Built 1991-2000	-.045	.073	Popular (Populus) dominant in street	-.041	.026
Built after 2001	-.012	.073	Oak (Quercus) dominant in street	.040	.026
Neighbourhoods			Alder (Alnus) dominant in street	-.001	.022
Apartment	-.033***	.007	Willow (Salix) dominant in street	.122***	.029
No. Rooms	.007***	.001	Birch (Betula) dominant in street	-.040	.024
No. Floors	-.006	.003	Cherry (Prunus) dominant in street	-.037	.019
Parking spot, cohort or garage [c]	.027***	.006	Hawthorn (Crataegus) dominant in street	-.010	.020
Boiler or central heating [d]	.113***	.013	Hornbeam (Carpinus) dominant in street	-.043	.021
Airconditioning or solar panels [d]	.228	.105	Acacia (Robinia) dominant in street	.0002	.018
Balcony or roof terrace [e]	.003	.004	Horse chestnut (Aesculus) dominant in street	.033	.040
Garden [f]	.021***	.003			
Permanent ground lease [g]	-.009	.005	Total monumental trees per street	.0007*	.009
Varying ground lease [g]	-.069***	.006	Monumental tree is Elm (Ulmus)	.0009	.019
			Monumental tree is Linden (Tilia)	.007	.006
Ln. Distance to nearest tree (m)	.005	.002	Monumental tree is Maple (Acer)	.011	.012
Ln. Distance to nearest tram or metro [j]	.007	.002	Monumental tree is Ash (Fraxinus)	-.067	.066
Ln. Distance to nearest public sports field [k]	-.006	.002	Monumental tree is Plane (Platanus)	-.003	.015
Ln. trees per street (per 100m)	.003	.002	Monumental tree is Popular (Populus)	-.031	.015
Tree planted two years before property	-.005	.004	Monumental tree is Oak (Quercus)	-.012	.029
Total trees within 10m of property [i]	.002	.002	Monumental tree is Alder (Alnus)	.066	.071
Ln. total trees within 10-50m of property [i]	-.001	.003	Monumental tree is Willow (Salix)	-.014	.021
Ln. total trees within 50-100m of property [i]	-.0009	.006	Monumental tree is Birch (Betula)	-.014	.016
Most trees in street are 0 – 6 metres high	.007	.006	Monumental tree is Cherry (Prunus)	-.128	.038
Most trees in street are 6 – 9 metres high	.010	.006	Monumental tree is Hawthorn (Crataegus)	.029	.024
Most trees in street are 9-12 metres high	.003	.006	Monumental tree is Hornbeam (Carpinus)	.029	.010
Most trees in street are 12-15 metres high	.007	.007	Monumental tree is Acacia (Robinia)	-.128	.075
Most trees in street are 15-18 metres high	.007	.006	Monumental tree is Horse chestnut (Aesculus)	-.196	.153
Most trees in street are 18-25 metres high	.016	.009			
Most trees in street are 24 metres or higher	-.007	.018			
Constant	10.54***	.104			
R-squared	.5649				

Dependent variable is the log of sales price higher than 500.000 EUR. N=7,543. *p<0.1 **p<0.05. ***P<0.01.

APPENDIX B: CORRELATION MATRIX

TABLE 12: VARIABLES.

Variable	Label		
Ln. Property price	1	Total Birch (Betula) per street	26
Neighbourhoods	2	Total Cherry (Prunus) per street	27
Ln. Total liveable surface (M2)	3	Total Hawthorn (Crataegus) per street	28
Building period	4	Total Hornbeam (Carpinus) per street	29
Apartment	5	Total Acacia (Robinia) per street	30
No. Rooms	6	Total Horse chestnut (Aesculus) per street	31
No. Floors	7	Dominant species per street	32
Parking spot, cohort or garage	8	Tree up to 6m high	33
Balcony or roof terrace	9	Trees 6 – 9m high per street	34
Boiler or central heating	10	Trees 9-12m high per street	35
Garden	11	Trees 12-15m high per street	36
Ground lease	12	Trees 15-18m high per street	37
Ln. Total trees per street (per 100m)	13	Trees 18-24m high per street	38
Total trees within 10m of property	14	Trees 24m or higher per street	39
Ln. Total trees within 10-50m of property	15	Dominant tree height per street	40
Ln. Total trees within 50-100m of property	16	Dominant tree type within 100m	41
Total Elm (Ulmus) per street	17	Dominant tree height within 100m	42
Total Linden (Tilia) per street	18	Number of monumental trees per street	43
Total Maple (Acer) per street	19	Monumental tree within 100m	44
Total Ash (Fraxinus) per street	20	Tree species of monumental tree	45
Total Plane (Platanus) per street	21	Tree planted 2 years before property sale	46
Total Popular (Populus) per street	22	Ln. distance to public nearest tree (m)	47
Total Oak (Quercus) per street	23	Distance to nearest park (m)	48
Total Alder (Alnus) per street	24	Ln. distance to nearest tram or metro (m)	49
Total Willow (Salix) per street	25	Ln. distance to nearest public sports field	50

TABLE 13: CORRELATION MATRICES.

	1	2	3	4	5	6	7	8	9	10	11
1	1										
2	0.7801	1									
3	0.0322	-0.0022	1								
4	-0.0591	0.1917	-0.0033	1							
5	-0.189	-0.4295	0.0438	-0.2109	1						
6	0.1931	0.2778	-0.002	0.0545	-0.4907	1					
7	0.4741	0.6383	-0.0097	0.0621	-0.6479	0.3709	1				
8	0.5804	0.778	-0.0015	0.0883	-0.4328	0.2478	0.6376	1			
9	0.1724	0.257	0.0072	0.3787	-0.1829	0.066	0.12	0.1378	1		
10	0.2391	0.1795	0.0229	-0.0856	0.0331	-0.0065	0.1967	0.1651	-0.008	1	
11	0.1169	0.1215	-0.0033	0.155	-0.0328	0.0366	0.0472	0.0882	0.0615	0.0358	1
12	-0.1393	0.017	-0.0221	0.158	-0.0199	-0.0087	-0.0342	0.0209	0.0486	-0.0457	0.008
13	-0.1289	0.0197	-0.0515	0.1532	-0.0309	-0.0333	-0.0502	0.0291	0.0863	-0.0505	0.0517

	1	2	3	4	5	6	7	8	9	10	11
14	-0.0523	-0.0022	-0.0091	0.0301	-0.0117	-0.0072	-0.0134	0.0078	0.0037	-0.0203	0.0128
15	-0.115	-0.0015	-0.0164	0.0542	-0.035	0.0001	-0.0237	0.0432	-0.031	-0.0262	0.0332
16	-0.1632	0.0044	-0.0181	0.109	-0.059	0.0082	-0.0325	0.0654	-0.0186	-0.0439	0.0462
17	0.0181	0.0081	0.0043	-0.0033	0.0029	0.0004	0.0048	0.0045	0.0023	-0.0004	0.0026
18	0.0034	0.0063	0.006	-0.0023	-0.0006	-0.0005	0.0007	0.008	-0.0015	0.0093	0.0059
19	-0.0053	0.0077	-0.0009	0.0169	-0.0171	0.0079	0.0093	0.0075	0.0079	-0.0012	0.0067
20	-0.0058	0.0114	-0.004	0.0178	-0.0265	0.0178	0.014	0.0103	0.0109	0.0019	0.0074
21	0.0084	0.0077	-0.0017	0.0071	0.0007	-0.0002	-0.0006	0.0032	0.0065	0.0027	0.0025
22	0.0018	0.0087	0.0044	0.0149	-0.0057	0.0043	0.0051	0.0061	0.0201	0.0036	0.0017
23	-0.0054	0.0098	-0.0008	0.0162	-0.014	0.0143	0.0114	0.0096	0.0016	-0.0012	0.0073
24	-0.0088	0.0044	-0.0066	0.0154	-0.0162	0.0073	0.0071	0.0069	0.0111	0.003	0.0056
25	0.0002	0.0177	-0.0024	0.0218	-0.0236	0.011	0.0142	0.0174	0.0129	-0.0024	0.007
26	-0.0002	0.0162	-0.0047	0.0222	-0.0248	0.0164	0.0149	0.0107	0.0193	-0.0029	0.0079
27	-0.0026	0.0062	-0.0064	0.0087	-0.0099	0.0027	0.0034	0.0091	0.0058	0.0045	0.0028
28	0.0132	0.011	-0.0049	-0.008	-0.002	-0.0023	0.004	0.0113	0.0004	0.0084	0.0025
29	0.0038	0.0072	0.0076	0.0015	-0.003	0.0065	0.0044	0.0069	0.0022	0.0002	0.005
30	0.0028	0.003	-0.0006	0.0011	0.0041	-0.0031	-0.0007	0.0009	-0.0003	0.0053	0.0009
31	-0.0166	0.0222	-0.0364	0.0415	-0.0302	0.048	0.0218	0.0342	0.0123	0.0197	0.0051
32	0.0099	0.0548	0.0351	0.111	-0.0838	0.0544	0.0656	0.0445	0.055	-0.0066	0.017
33	-0.0213	0.0122	-0.044	0.0268	-0.027	0.0146	0.0134	0.0287	0.013	0.0049	-0.0059
34	0.0135	-0.0222	0.0242	-0.0212	0.0341	-0.016	-0.02	-0.0292	-0.0284	-0.0098	0.0086
35	0.0064	-0.0064	-0.0528	-0.0547	0.0201	-0.0056	-0.0148	0.0022	-0.0251	0.0214	-0.0113
36	0.0162	-0.0323	0.0176	-0.0761	0.048	-0.0249	-0.0347	-0.0391	-0.0328	-0.0049	-0.0205
37	-0.0175	-0.0115	0.0283	-0.0035	0.0332	-0.0395	-0.0289	-0.0092	0.0107	0.0015	0.0056
38	-0.0253	-0.0039	-0.023	0.0095	0.0027	-0.006	-0.0097	0.0004	0.0156	-0.0021	0.0056
39	0.003	-0.0555	0.0518	-0.1115	0.0988	-0.0723	-0.0739	-0.057	-0.0152	0.0109	-0.0134
40	-0.0085	0.0158	-0.0289	0.0363	-0.0265	0.011	0.015	0.0193	0.0182	-0.0008	0.0013
41	-0.0081	-0.0273	0.0072	-0.02	0.0363	-0.0184	-0.0283	-0.0324	-0.0276	0.007	-0.0056
42	0.1584	0.0814	0.0608	-0.1174	-0.0006	0.013	0.0475	0.0209	-0.0094	0.0108	-0.0082
43	0.1169	0.0349	0.1156	-0.0988	0.0332	-0.0126	0.0033	-0.0086	-0.0082	0.0128	-0.0117
44	0.0967	0.0056	0.0842	-0.0941	0.0209	-0.009	0.0012	-0.0353	-0.013	0.0057	-0.0144
45	0.0075	-0.0028	0.1005	-0.0199	0.0595	-0.0299	-0.028	-0.0037	0.0536	0.0123	-0.0158
46	0.0967	0.0056	0.0842	-0.0941	0.0209	-0.009	0.0012	-0.0353	-0.013	0.0057	-0.0144
47	0.0497	0.0272	0.0181	0.0373	-0.0085	0.0033	0.0164	0.0045	0.0493	0.0023	0.007
48	-0.0036	0.0154	0.0415	0.026	-0.0382	0.0244	0.0352	0.0149	-0.0362	-0.0006	-0.0011
49	-0.1222	0.0694	-0.0271	0.1977	-0.3124	0.1599	0.1478	0.1001	0.0856	-0.0707	0.0526
50	-0.2579	0.0775	-0.0828	0.4437	-0.2598	0.0975	0.079	0.1158	0.1832	-0.0727	0.0729

	12	13	14	15	16	17	18	19	20	21	22
12	1										
13	0.1172	1									
14	0.0433	0.2253	1								
15	0.0937	0.4678	0.4239	1							
16	0.1311	0.5367	0.3366	0.7732	1						
17	-0.0055	-0.0043	-0.0039	-0.0062	-0.0128	1					
18	0.0054	0.0109	0.0059	0.0118	0.0141	0.2215	1				
19	0.0062	0.0315	0.0081	0.0157	0.0207	0.3076	0.3242	1			
20	0.0094	0.0303	0.0122	0.0148	0.0215	0.1577	0.2747	0.4608	1		
21	0.0086	0.0077	0.0093	0.0078	0.0055	0.2088	0.2561	0.25	0.2169	1	
22	0.0051	0.017	0.0001	0.0002	0.0042	0.1881	0.2477	0.3115	0.2378	0.1859	1
23	0.0034	0.0222	0.0078	0.0094	0.0149	0.3276	0.1909	0.3591	0.2657	0.1623	0.1872
24	0.0063	0.0213	0.0088	0.0036	0.0115	0.1247	0.2339	0.3789	0.4272	0.1789	0.3936
25	0.0043	0.023	0.0063	0.0091	0.0133	0.1457	0.2036	0.3461	0.3694	0.1856	0.2727
26	0.0059	0.0313	0.0089	0.0161	0.0221	0.1154	0.2019	0.3788	0.3628	0.2187	0.1767
27	0.0061	0.0156	0.0065	0.0142	0.0187	0.1701	0.3694	0.358	0.245	0.1963	0.2088
28	-0.0031	0.0175	0.0095	0.0102	0.0144	0.2129	0.2484	0.2772	0.2776	0.2529	0.1937
29	-0.0024	0.0024	0.0046	0.0042	0.0063	0.1056	0.263	0.2359	0.157	0.1522	0.1789
30	0.0003	0.0024	-0.0019	0.0003	0.0014	0.1748	0.3254	0.2176	0.1139	0.2033	0.1918
31	0.003	0.0107	0.0045	0.0055	0.0046	0.1615	0.2886	0.226	0.1693	0.183	0.2756
32	0.014	0.1059	0.0595	0.1006	0.1277	-0.0255	-0.0153	-0.0054	-0.0039	0.0016	0.0065
33	0.0241	0.016	0.0164	0.0299	0.0429	-0.0026	-0.0002	0.0016	0.0001	-0.0035	-0.0039
34	0.0062	0.0053	-0.0174	-0.0082	0.0308	-0.0097	-0.0035	-0.001	-0.0028	-0.0064	-0.0042
35	-0.0101	-0.037	-0.0136	-0.0315	-0.0544	-0.0043	-0.0031	-0.0018	0.0004	0.0021	-0.0034
36	-0.0025	0.0022	-0.0017	-0.0031	-0.0006	0.0005	0.0016	0.0049	0.0032	-0.0028	-0.0004
37	-0.0226	-0.027	0.0027	-0.0038	-0.0301	0.0113	0.0043	-0.0036	-0.0034	0.0042	-0.0022
38	0.01	0.0421	0.0232	0.0419	0.0406	0.0089	0.0027	0.0023	0.0022	0.0086	0.0076
39	0.016	0.0591	0.0072	0.0029	0.024	-0.0045	-0.0033	-0.0026	0.0012	-0.0045	0.0213
40	-0.0152	0.0498	0.0084	0.0137	-0.0327	0.0166	0.0072	-0.0028	-0.0031	0.0154	0.0193
41	0.0152	0.0375	0.028	0.0299	0.0305	-0.0053	0.0029	0.006	-0.0011	-0.0116	-0.0013
42	-0.0042	-0.03	-0.0254	-0.0398	-0.0558	0.0009	-0.007	-0.0032	-0.0022	-0.0046	-0.0036
43	-0.0514	0.0148	0.0039	-0.0444	-0.0692	0.0196	-0.0031	0.0058	0.0019	0.0096	0.0045
44	-0.056	-0.057	-0.0039	-0.0611	-0.1014	0.0126	0.0004	0.0023	0.0003	0.0087	0.0111
45	-0.0643	-0.0434	-0.0018	-0.065	-0.1179	0.0152	-0.0055	0.0026	-0.0009	0.0102	0.0047
46	-0.0065	0.0798	0.0174	0.0266	0.0237	-0.0001	-0.0032	0.0036	-0.0028	-0.002	0.0009
47	-0.0229	-0.2022	-0.6987	-0.443	-0.3069	0.0011	-0.009	-0.0074	-0.0071	-0.0098	0.0002
48	0.0116	-0.069	-0.0477	-0.0475	-0.0423	0.0034	0.003	-0.0021	0.003	-0.0001	-0.0028
49	0.0694	0.2863	0.0923	0.1852	0.2426	-0.0054	0.0037	0.021	0.0314	-0.0029	0.0111
50	0.1537	0.4059	0.0939	0.228	0.3456	-0.0206	0.0029	0.0232	0.0266	0.003	0.0017

	23	24	25	26	27	28	29	30	31	32	33
23	1										
24	0.2487	1									
25	0.2038	0.3122	1								
26	0.2338	0.2872	0.2642	1							
27	0.1501	0.2461	0.2007	0.2545	1						
28	0.1944	0.2263	0.1886	0.1983	0.292	1					
29	0.152	0.1145	0.1679	0.2164	0.2307	0.1548	1				
30	0.1383	0.1489	0.1114	0.1123	0.2845	0.1439	0.1787	1			
31	0.1161	0.1843	0.1599	0.1397	0.2377	0.1424	0.2056	0.1534	1		
32	0.0056	0.0131	0.0126	0.0226	0.0303	0.0203	0.0218	0.0318	0.0202	1	
33	-0.0005	-0.0058	0.0111	0.005	0.0073	0.0054	0.0093	0.003	-0.0012	0.1012	1
34	-0.0001	0.0009	-0.0025	0.0079	0.007	0.0031	-0.0006	-0.0024	-0.0008	0.0748	-0.2018
35	-0.0054	0.0036	-0.0062	-0.003	0.0004	-0.0033	-0.0078	-0.0026	0.0033	-0.0375	-0.2667
36	0.0055	0.0053	0.0015	-0.0031	-0.0004	0.0064	0.0032	0.0086	0.001	0.0135	-0.1812
37	-0.0023	-0.0038	-0.0072	-0.0036	-0.0099	-0.0074	-0.0052	-0.0048	-0.0046	-0.0793	-0.2182
38	0.0057	-0.0022	0.0004	-0.0052	-0.0077	-0.002	-0.0007	0.0005	-0.0028	-0.0852	-0.1307
39	-0.0024	0.0036	0.0016	-0.0005	-0.0046	-0.0012	-0.0024	-0.0047	-0.0001	-0.0052	-0.0654
40	0.0026	0.0012	-0.0105	-0.0097	-0.0248	-0.0097	-0.0086	-0.0027	0.0007	-0.2094	-0.2477
41	0.0064	0.0039	0.0075	0.0048	0.0121	0.0026	0.0006	0.011	-0.003	0.0835	0.0143
42	-0.0002	-0.0022	-0.0107	-0.0045	-0.0094	0.0007	-0.0087	0.0014	0.0008	-0.0254	-0.1154
43	0.002	-0.0029	0.0029	-0.0017	-0.0024	-0.0007	0.0057	-0.0041	0.0055	-0.0829	-0.0014
44	-0.006	-0.004	-0.0007	-0.0054	0.0026	0.0015	0.0045	0.0005	0.0088	-0.0833	0.0131
45	-0.0043	-0.002	-0.0029	-0.0032	0.001	0.0046	-0.0018	-0.0014	0.0043	-0.0799	-0.0004
46	-0.0012	-0.0006	0.0016	0.0016	-0.0065	0.0019	-0.0038	0.0022	0.003	0.0243	0.0879
47	-0.0063	-0.0027	-0.0018	-0.0071	-0.0077	-0.0051	-0.0036	-0.0029	-0.0058	-0.0477	0.0198
48	-0.0069	-0.0017	-0.0002	0.0024	-0.0034	-0.0055	-0.0015	0.0049	-0.0046	-0.0057	0.0033
49	0.0089	0.0243	0.0225	0.0201	0.0092	0.0109	-0.0065	-0.0049	0.0047	0.0572	0.027
50	0.0201	0.0255	0.0309	0.0268	0.0115	-0.0045	0.0038	0.0031	0.0027	0.1247	0.1125

	34	35	36	37	38	39	40	41	42	43	44
34	-0.2425	1									
35	-0.1648	-0.2178	1								
36	-0.1985	-0.2623	-0.1782	1							
37	-0.1189	-0.1571	-0.1067	-0.1285	1						
38	-0.0594	-0.0785	-0.0534	-0.0643	-0.0385	1					
39	-0.1373	0.0334	0.0614	0.1886	0.1516	0.0103	1				
40	0.0485	0.0299	0.0298	-0.0737	-0.0566	-0.0665	-0.0703	1			
41	0.059	0.0959	-0.0294	-0.0193	0.0084	0.0043	0.0392	0.0007	1		
42	-0.0636	0.0238	-0.054	0.0773	0.0181	0.003	0.1148	-0.0569	0.0114	1	
43	-0.1109	0.0291	-0.0817	0.1258	0.0088	0.0131	0.1171	-0.069	-0.0258	0.5478	1
44	-0.0983	0.0356	-0.0726	0.1021	0.0275	0.0055	0.1194	-0.0507	-0.0052	0.5245	0.8341
45	0.0196	0.0117	-0.0781	-0.0391	-0.0197	0.0078	-0.0886	0.0224	-0.0268	0.111	0.1298
46	-0.0983	0.0356	-0.0726	0.1021	0.0275	0.0055	0.1194	-0.0507	-0.0052	0.5245	0.8341
47	0.0187	-0.0032	-0.0092	-0.016	-0.0204	0.0035	-0.0293	-0.0098	0.0174	0.0074	0.019
48	-0.0311	0.0141	-0.0236	0.0369	-0.02	-0.006	0.0285	-0.0171	-0.0015	0.0203	0.0221
49	-0.0087	-0.0248	0.0213	-0.0228	-0.001	0.0071	-0.0225	-0.0033	-0.0133	-0.0553	-0.1122
50	0.0701	-0.0931	0.0315	-0.1237	0.0024	0.0391	-0.143	0.0593	-0.0651	-0.1737	-0.2359

	45	46	47	48	49	50
45	1					
46	0.0653	1				
47	-0.0041	0.0081	1			
48	0.0154	-0.0108	0.0197	1		
49	-0.0985	-0.0752	-0.0626	0.0236	1	
50	0.0237	-0.2248	-0.0486	-0.0075	0.3469	1

APPENDIX C: TREE SPECIES


Elm[A]


Linden[B]


Maple[C]


Ash[D]


Plane[E]


Poplar[F]


Oak[G]


Alder[H]

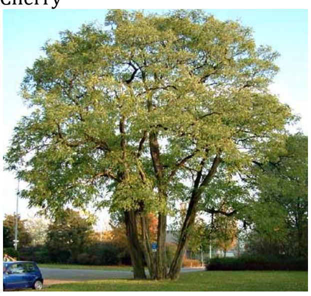

Willow[I]


Birch[J]


Cherry[K]


Hawthorn[L]


Hornbeam[M]


Acacia[N]


Horse chestnut[O]

FIGURE 11: Tree species.

TABLE 14: MOST COMMON SPECIES IN AMSTERDAM

Name of Tree (Latin name)	Number of trees in Amsterdam	Number of trees in dataset	Amount of times the species is dominant in a street
Elm (Ulmus)	31.148	11,267	34,319
Linden (Tilia)	25.811	7,855	18,457
Maple (Acer)	25.525	4,488	8,026
Ash (Fraxinus)	19.678	2,757	3,890
Plane (Platanus)	15.582	4,877	9,865
Poplar (Populus)	13.926	1,771	1,527
Oak (Quercus)	13.901	2,020	1,718
Alder (Alnus)	12.704	2,084	4,237
Willow (Salix)	11.650	1,599	1,116
Birch (Betula)	11.427	1,886	2,586
Cherry (Prunus)	11.318	3,190	4,558
Hawthorn (Crataegus)	6.291	1,673	2,200
Hornbeam (Carpinus)	6.276	1,533	2,366
Acacia (Robinia)	5.975	2,373	4,531
Horse chestnut (Aesculus)	4.387	1,160	1,107

Source: GISIB - Beheersysteem Openbare Ruimte, Gemeente Amsterdam, januari 2018.

TABLE 15: TREE CHARACTERISTICS BY SPECIES

Name of Tree (Latin name)	Max, height (metres)	diameter	Leaf (cm)	Shadow tolerance (1-5)	Dryness tolerance (1-5)	Blossom period	age
Elm (Ulmus)	23-34	4-5	6-13	R 3.0	R 3.0	March	150-200
Linden (Tilia)	24-37	6-9	6-10	R-H 3.5	R 3.0	June	300-400
Maple (Acer)	24-37	3-5	15-30	H 3.7	R 2.8	April-May	100-200
Ash (Fraxinus)	21,4-39,5	3,5-4,8	9-12	R 2,7	R 2,5	April	150-200
Plane (Platanus)	32-39	6-8	13-21	R 3	R 3.4	May	> 400
Poplar (Populus)	33-41	6-8	5-13	L 1,7	L 1,8	March-April	80-150
Oak (Quercus)	37-42	7-10	8-11	R 2,5	R 3.0	May	200-400
Alder (Alnus)	21-33	2-4	5-9	R. 2.7	L 2.2	March	80-160
Willow (Salix)	21-34	3-7	7-15	L	low	April-May	60-80
Birch (Betula)	23-32	1-3	3-6	L 2.1	high	April-May	60-100
Cherry (Prunus)	15-32	0,9-1,2	8-15	R	L	April-May	100-150
Hawthorn (Crataegus)	5-8	-	4-5	L	high	May	>100
Hornbeam (Carpinus)	24-34	2-4	5-11	High 4,0	Low 2,7	April	150-250
Acacia (Robinia)	20-30	0,5	10-20	L	R	June	150-200
Horse chestnut (Aesculus)	19-36	2-6	10-20	R 3-3.4	R 2,8	April-may	100-200

L = low; R = reasonably; H = high.

APPENDIX D: NEIGHBOURHOODS OF AMSTERDAM

TABLE 17: NEIGHBOURHOODS OF AMSTERDAM

Neighbourhood
Aalsmeerwegbuurt Oost
Aalsmeerwegbuurt West
Afrikahaven
Alexanderplein e.o.
Alfa-driehoek
AMC
Amerikahaven
Amstel III deel A/B Noord
Amstel III deel A/B Zuid
Amstel III deel C/D Noord
Amstel III deel C/D Zuid
Amstelglorie
Amstelkwartier Noord
Amstelkwartier West
Amstelkwartier Zuid
Amstelpark
Amstelveldbuurt
Amsterdamse Bos
Amsterdamse Poort
Andreasterrein
Anjeliersbuurt Noord
Anjeliersbuurt Zuid
Architectenbuurt
Balboaplein e.o.
Banne Noordoost
Banne Noordwest
Banne Zuidoost
Banne Zuidwest
Banpleinbuurt
Beatrixpark
Bedrijvencentrum Osdorp
Bedrijvencentrum Westerkwartier
Bedrijvengebied Cruquiusweg
Bedrijvengebied Veelaan
Bedrijvengebied Zeeburgerkade
Bedrijvenpark Lutkemeer
Bedrijventerrein Hamerstraat
Bedrijventerrein Landlust
Bedrijventerrein Nieuwendammerdijk
Bedrijventerrein Schinkel
Bedrijventerrein Sloterdijk I
Beethovenbuurt
Begijnhofbuurt
Belgiëplein e.o.
Bellamybuurt Noord
Bellamybuurt Zuid
Bertelmanpleinbuurt
Betondorp
BG-terrein e.o.
Bijlmermuseum Noord
Bijlmermuseum Zuid
Bijlmerpark Oost
Bijlmerpark West
Blauwe Zand
Bloemenbuurt Noord
Bloemenbuurt Zuid
Bloemgrachtbuurt
Borgerbuurt
Borneo
Bosleeuw
Bretten Oost
Bretten West
Buiksloterbreek
Buiksloterdijk Oost
Buiksloterdijk West
Buiksloterham
Buitenveldert Midden Zuid
Buitenveldert Oost Midden
Buitenveldert West Midden
Buitenveldert Zuidoost
Buitenveldert Zuidwest
Burgemeester Tellegenbuurt Oost
Burgemeester Tellegenbuurt West
Burgwallen Oost
Buurt 10
Buurt 2
Buurt 3
Buurt 4 Oost
Buurt 5 Noord
Buurt 5 Zuid
Buurt 6
Buurt 7
Buurt 8
Buurt 9
Buyskade e.o.
Calandlaan/Lelylaan
Centrumeiland
Circus/Kermisbuurt
Coenhaven/Mercuriushaven
Columbusplein e.o.
Concertgebouwbuurt
Cornelis Douwesterrein
Cornelis Schuytbuurt
Cornelis Troostbuurt
Cremerbuurt Oost
Cremerbuurt West
Czaar Peterbuurt
D-buurt
Da Costabuurt Noord
Da Costabuurt Zuid
Dapperbuurt Noord
Dapperbuurt Zuid
De Aker Oost
De Aker West
De Bongerd
De Eenhoorn
De Heining
De Kleine Wereld
De Klenckebuurt
De Omval
De Punt
De Wester Quartier
De Wetbuurt
De Wittenbuurt Noord
De Wittenbuurt Zuid
Delflandpleinbuurt Oost
Delflandpleinbuurt West
Den Texbuurt
Diamantbuurt
Diepenbrockbuurt
Don Bosco
Dorp Driemond
Dorp Sloten
Drieburg
Driehoekbuurt
Duivelseiland
Durgerdam
E-buurt
Ecowijk
Eendrachtspark
Elandsgrachtbuurt
Entrepot-Noordwest
Erasmusparkbuurt Oost
Erasmusparkbuurt West
F-buurt
Fannius Scholtenbuurt
Felix Meritisbuurt
Filips van Almondekwartier
Flevopark
Frankendael
Frans Halsbuurt
Frederik Hendrikbuurt Noord
Frederik Hendrikbuurt Zuidoost
Frederik Hendrikbuurt Zuidwest
Frederikspleinbuurt
G-buurt Noord
G-buurt Oost
G-buurt West
Gaasperdam Noord
Gaasperdam Zuid
Gaasperpark
Gaasperplas
Gein Noordoost
Gein Noordwest
Gein Zuidwest
Gein Zuioost
Gelderlandpleinbuurt
Gerard Doubuurt
Geuzenhofbuurt
Gibraltarbuurt
Gouden Bocht
Groenmarktkadebuurt
Grunder/Koningshoef
Haarlemmerbuurt Oost
Haarlemmerbuurt West
Hakfort/Huigenbos
Harmoniehofbuurt
Haveneiland Noord
Haveneiland Noordoost
Haveneiland Noordwest
Haveneiland Oost
Haveneiland Zuidwest/Rieteiland West
Helmersbuurt Oost
Hemelrijk
Hemonybuurt
Hercules Seghersbuurt
Het Funen
Hiltonbuurt
Hoge Dijk
Holendrecht Oost
Holendrecht West
Holysloot
Hoptille
Houthavens Oost
Houthavens West
Huntum
IJplein e.o.
IJsbaanpad e.o.
IJselbuurt Oost
IJselbuurt West
Jacob Geelbuurt
Jacques Veldmanbuurt
Jan Maijenbuurt
Java-eiland
Johan Jongkindbuurt
Johannnes Vermeerbuurt
John Franklinbuurt
Julianapark
K-buurt Midden
K-buurt Zuidoost
K-buurt Zuidwest
Kadijken
Kadoelen
Kalverdriehoek
Kantershof
Kattenburg
Kazernebuurt
Kelbergen
KNSM-eiland
Kolenkitbuurt Noord
Kolenkitbuurt Zuid
Koningin Wilhelminaplein
Kop Zeedijk
Kop Zuidas
Kortenaerkwartier
Kortvoort
Kromme Mijdrechtbuurt
L-buurt
Laan van Spartaan
Landelijk gebied Driemond
Landlust Noord
Landlust Zuid
Langestraat e.o.
Lastage
Legmeerpleinbuurt
Leidsebuurt Noordoost
Leidsebuurt Noordwest
Leidsebuurt Zuidoost
Leidsebuurt Zuidwest
Leidsegracht Noord
Leidsegracht Zuid
Leliegracht e.o.
Linnaeusparkbuurt
Lizzy Ansinghbuurt
Loenermark
Lootsbuurt
Louis Crispijnbuurt
Lucas/Andreasziekenhuis e.o.
Marathonbuurt Oost
Marathonbuurt West
Marcanti
Marjoleinterrein
Markengouw Midden
Markengouw Noord
Markengouw Zuid
Markthallen
Marnixbuurt Zuid
Medisch Centrum Slotervaart
Meer en Oever
Mercatorpark
Middelveldsche Akerpolder
Middeneiland Noordoost
Middeneiland Noordwest
Middeneiland Zuidoost
Middeneiland Zuidwest
Middenmeer Noord
Middenmeer Zuid
Minervabuurt Midden
Minervabuurt Noord
Minervabuurt Zuid
Molenwijk
Museumplein
NDSM terrein
Nes e.o.
Nieuw Sloten Noordoost
Nieuw Sloten Noordwest
Nieuw Sloten Zuidoost
Nieuw Sloten Zuidwest
Nieuwe Diep/Diemerpark
Nieuwe Kerk e.o.
Nieuwe Meer
Nieuwe Oosterbegraafplaats
Nieuwendammerdijk Oost
Nieuwendammerdijk Zuid
Nieuwendammmerdijk West
Nieuwendijk Noord
Nieuwmarkt
Nintemanterrein
Noorder IJplas
Noorderstrook Oost
Noorderstrook West
Noordoever Sloterplas
Noordoostkwadrant Indische buurt
Noordwestkwadrant Indische buurt Noord
Noordwestkwadrant Indische buurt Zuid
Olympisch Stadion e.o.
Ookmeer
Oostelijke Handelskade
Oostenburg
Oosterdokseiland
Oosterpark
Oosterparkbuurt Noordwest
Oosterparkbuurt Zuidoost
Oosterparkbuurt Zuidwest

Buikslotermeer Noord	Elzenhagen Noord	Hondecoeterbuurt	Marine-Etablissement	Oostoever Sloterplas
Buikslotermeerplein	Elzenhagen Zuid	Hoofdcentrum	Marnixbuurt Midden	Oostpoort
Buiteneiland	Emanuel van Meterenbuurt	Zuidoost	Marnixbuurt Noord	Oostzanerdijk

Neighbourhood			
Orteliusbuurt Midden	Schipluidenbuurt	Venserpolder Oost	Zuidwestkwadrant
Orteliusbuurt Noord	Science Park Noord	Vervoerscentrum	Osdorp Zuid
Orteliusbuurt Zuid	Science Park Zuid	Vliegenbos	Zunderdorp
Osdorp Midden Noord	Sloterdijk II	Vogelbuurt Noord	Zwarte Gouw
Osdorp Midden Zuid	Sloterdijk III Oost	Vogelbuurt Zuid	
Osdorp Zuidoost	Sloterdijk III West	Vogeltjeswei	
Osdorper Binnenpolder	Slotermeer Zuid	Vondelpark Oost	
Osdorper Bovenpolder	Sloterpark	Vondelpark West	
Osdorpplein e.o.	Sloterweg e.o.	Vondelparkbuurt	
	Spaarndammerbuurt	Midden	
Oude Kerk e.o.	Midden	Vondelparkbuurt Oost	
Overamstel	Spaarndammerbuurt	Vondelparkbuurt	
Overbraker Binnenpolder	Noordoost	West	
Overhoeks	Spaarndammerbuurt	VU-kwartier	
Overtoomse Veld Noord	Noordwest	Walvisbuurt	
Overtoomse Veld Zuid	Spaarndammerbuurt	Waterloopleinbuurt	
P.C. Hooftbuurt	Zuidoost	Weesperbuurt	
Papaverweg e.o.	Spaarndammerbuurt	Weespertrekvaart	
Paramariboplein e.o.	Zuidwest	Weesperzijde	
Park de Mees	Spiegelbuurt	Midden/Zuid	
Park Haagseweg	Sporenburg	Werengouw Midden	
Parooldriehoek	Sportpark Middenmeer	Werengouw Noord	
Passeerdersgrachtbuurt	Noord	Werengouw Zuid	
Petroleumhaven	Sportpark Middenmeer Zuid	Westelijke eilanden	
Pieter van der Doesbuurt	Sportpark Voorland	Westerdokseiland	
Plan van Gool	Spuistraat Noord	Westergasfabriek	
Planciusbuurt Noord	Spuistraat Zuid	Westerstaatsman	
Planciusbuurt Zuid	Staalmanbuurt	Westhaven Noord	
Plantage	Staatsliedenbuurt	Westhaven Zuid	
Postjeskade e.o.	Noordoost	Westlandgrachtbuurt	
Prinses Irenebuurt	Stationsplein e.o.	Weteringbuurt	
RAI	Steigereiland Noord	WG-terrein	
Ransdorp	Steigereiland Zuid	Wielingenbuurt	
Rapenburg	Strandeiland	Wildeman	
Rechte H-buurt	Surinamepleinbuurt	Willemsparkbuurt	
Reguliersbuurt	Swammerdambuurt	Noord	
Reigersbos Midden	Teleport	Willibrordusbuurt	
Reigersbos Noord	Terrasdorp	Wittenburg	
Reigersbos Zuid	Transvaalbuurt Oost	Woon- en	
Rembrandtpark Noord	Transvaalbuurt West	Groengebied	
Rembrandtpark Zuid	Trompbuurt	Sloterdijk	
Rembrandtpleinbuurt	Tuindorp Amstelstation	Zaagpoortbuurt	
RI Oost terrein	Tuindorp Frankendael	Zamenhofstraat e.o.	
Riekerhaven	Tuindorp Nieuwendam Oost	Zeeburgerdijk Oost	
Riekerpolder	Tuindorp Nieuwendam	Zeeburgereiland	
Rieteiland Oost	West	Noordoost	
Rietlanden	Tuindorp Oostzaan Oost	Zeeburgereiland	
Rijnbuurt Midden	Tuindorp Oostzaan West	Noordwest	
Rijnbuurt Oost	Twiske Oost	Zeeburgereiland	
Rijnbuurt West	Twiske West	Zuidoost	
Robert Scottbuurt Oost	Uilenburg	Zeeburgereiland	
Robert Scottbuurt West	Utrechtsebuurt Zuid	Zuidwest	
Rode Kruisbuurt	Valeriusbuurt Oost	Zeeheldenbuurt	
Sarphatiparkbuurt	Valeriusbuurt West	Zorgvlied	
Sarphatistrook	Valkenburg	Zuidas Noord	
Scheepvaarthuisbuurt	Van Brakelkwartier	Zuidas Zuid	
Scheldebuurt Midden	Van der Helstpleinbuurt	Zuiderhof	
Scheldebuurt Oost	Van der Kunbuurt	Zuiderkerkbuurt	
Scheldebuurt West	Van der Pekbuurt	Zuidoostkwadrant	
Schellingwoude Noord	Van Loonbuurt	Indische buurt	
Schellingwoude Oost	Van Tuyllbuurt	Zuidwestkwadrant	
Schellingwoude West	Velserpolder West	Indische buurt	
Schinkelbuurt Noord	Veluwebuurt	Zuidwestkwadrant	
Schinkelbuurt Zuid	Vivaldi	Osdorp Noord	

APPENDIX E: EXTRA MAPS OF GEOGRAPHICAL LOCATIONS OF VARIABLES

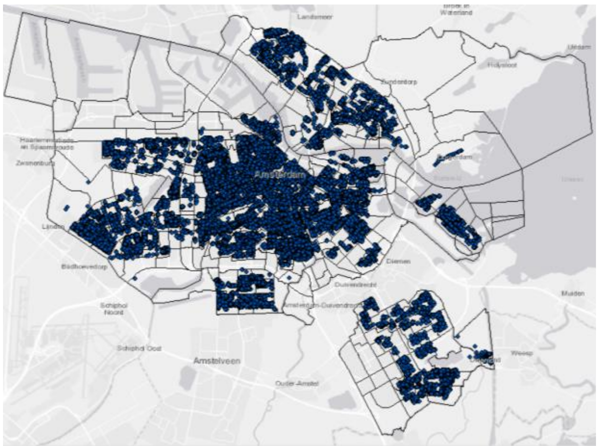


FIGURE 12: Geographical locations of the 100,503 NVM variables.

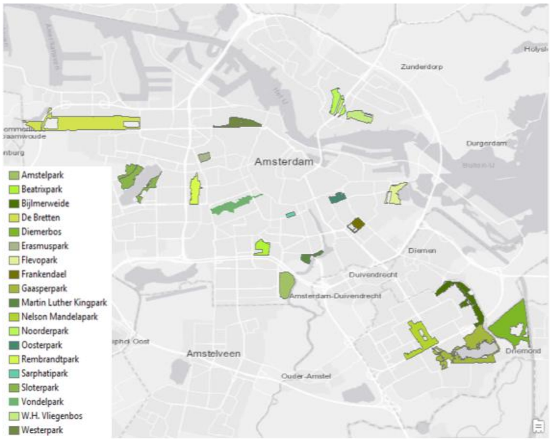
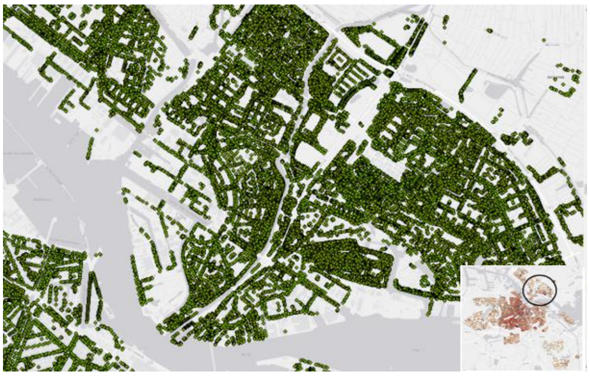


FIGURE 13: Public city parks in Amsterdam. Source: Municipality of Amsterdam 2019).

South

Southeast



North

East

Centre

West

FIGURE 14: Detailed maps of tree distributions.

APPENDIX F: HISTOGRAM OF RECENT PRICE AND M2

The variables 'recent sales price' and M2 were right skewed, after log transforming the variables are more normally distributed (see figures below).

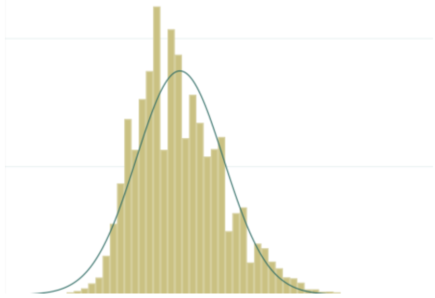


FIGURE 15: Histogram of the log of the variable 'recent sales price' .

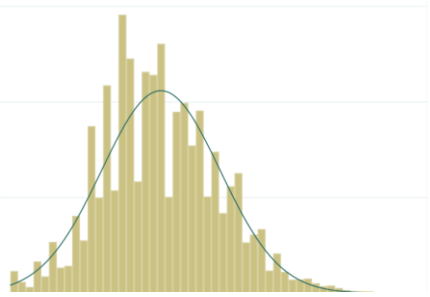


FIGURE 16: Histogram of log-transformed variable 'M2'.

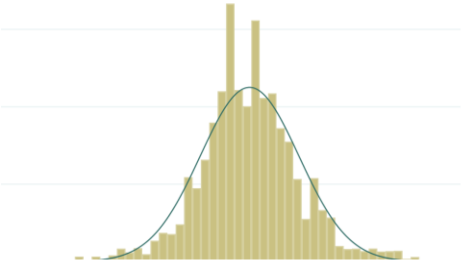


FIGURE 17: Histogram of log-transformed variable trees per street per 100m.

APPENDIX G: WOZ VALUE, INCOME AND TREE(S) (SPECIES)

Number of trees per neighbourhood (Y-as) and WOZ value per neighbourhood (2010) (x 1000).
The graph shows that in general, the lower the property price per neighbourhood the more the trees.

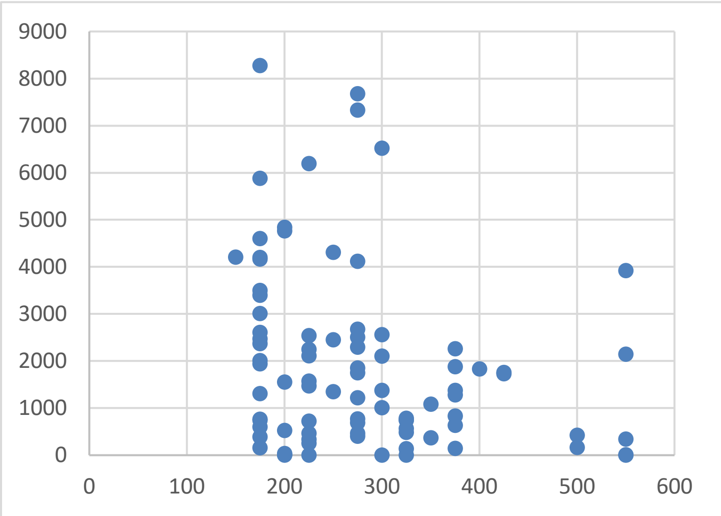


FIGURE 18: WOZ value per neighbourhood (2010) and the number of trees per neighbourhood

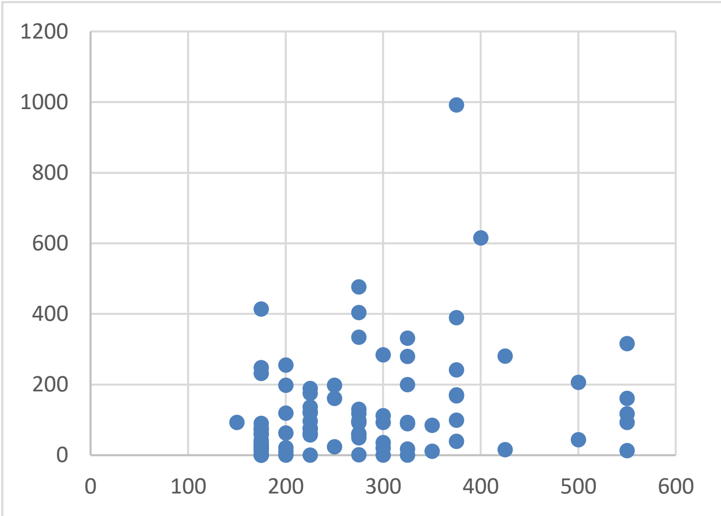


Figure 19: WOZ value & Elm tree.

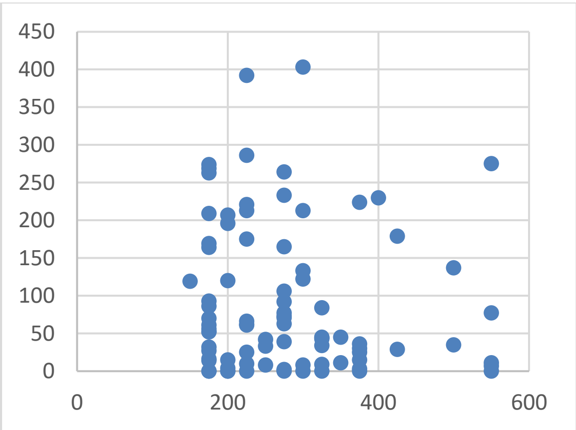


Figure 20: WOZ value & Linden tree.

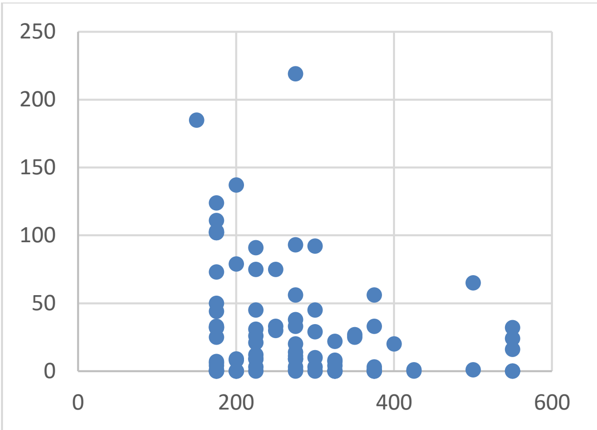


Figure 21: WOZ value & Ash tree.

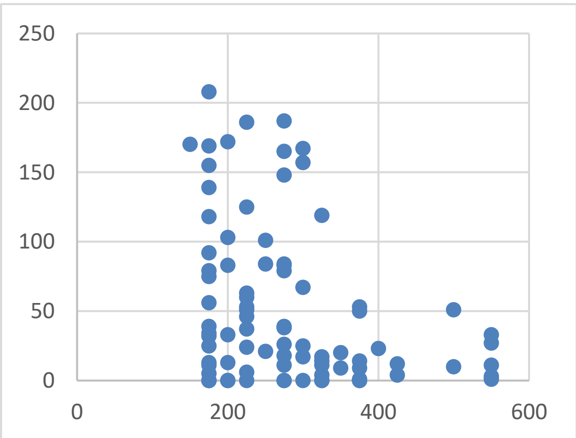


Figure 22: WOZ value & Maple tree.

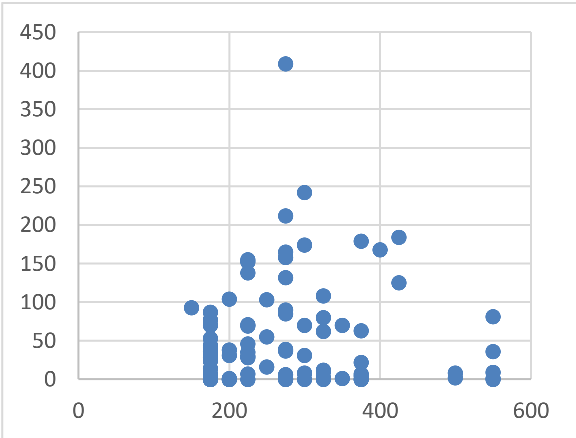


Figure 23: WOZ value & Plane tree.

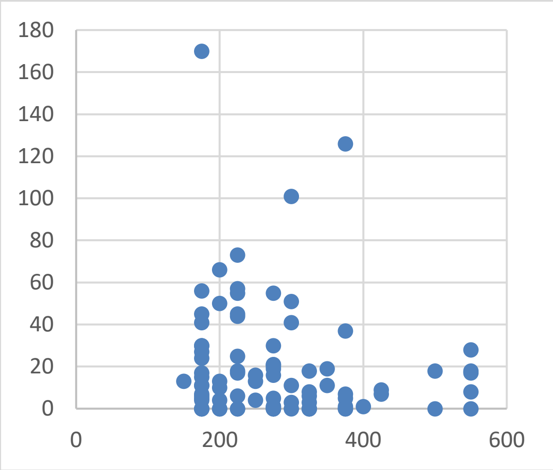


Figure 24: WOZ value & Popular tree.

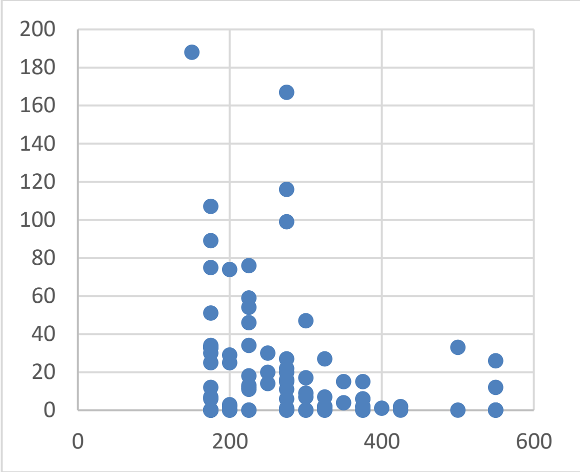


Figure 25: WOZ value & Oak tree.

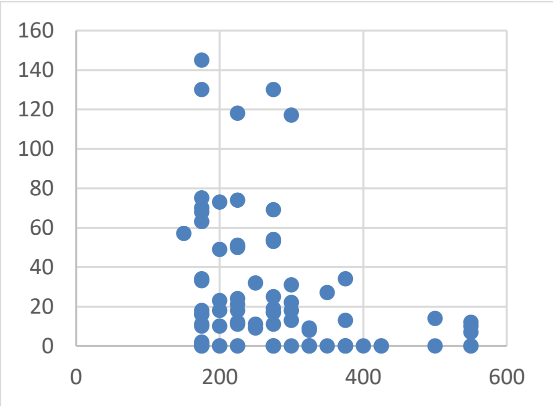


Figure 26: WOZ value & Alder tree.

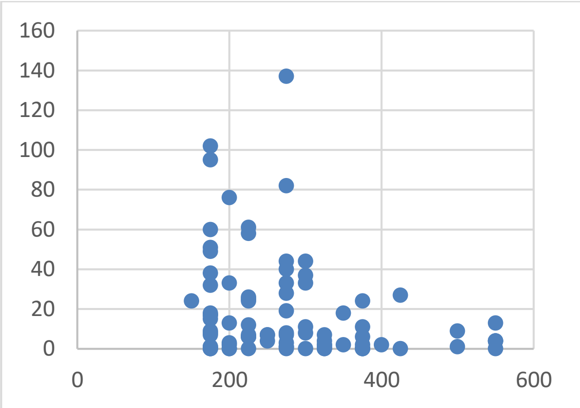


Figure 27: WOZ value & Willow tree.

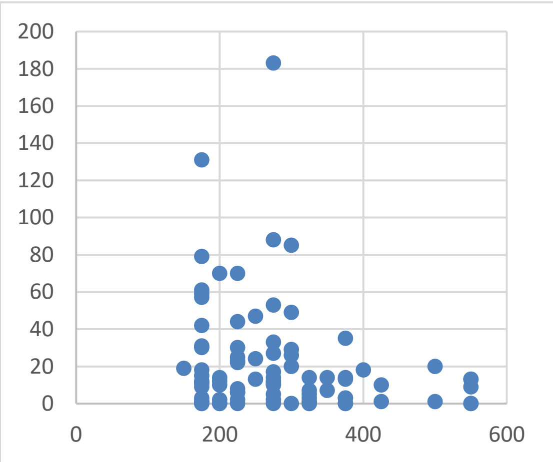


Figure 28: WOZ value & Birch tree.

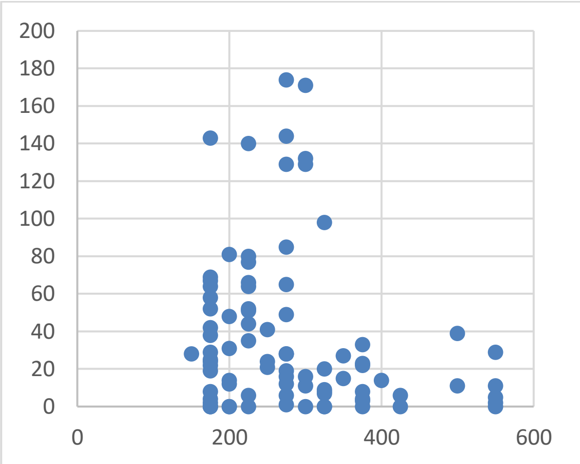


Figure 29: WOZ value & Cherry tree.

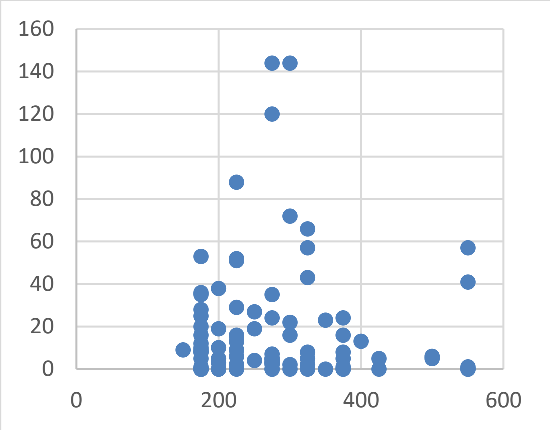


Figure 30: WOZ value & Hawthorn tree.

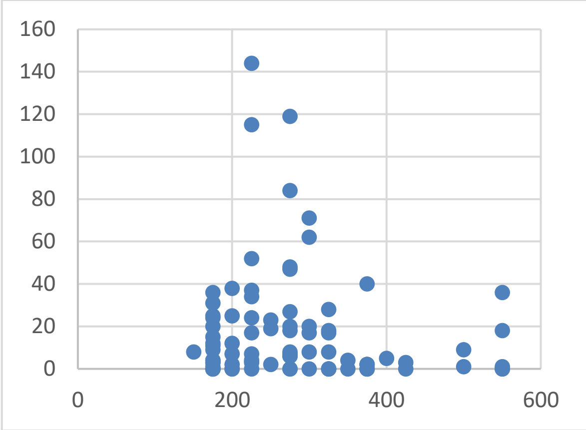


Figure 31: WOZ value & Hornbeam tree.

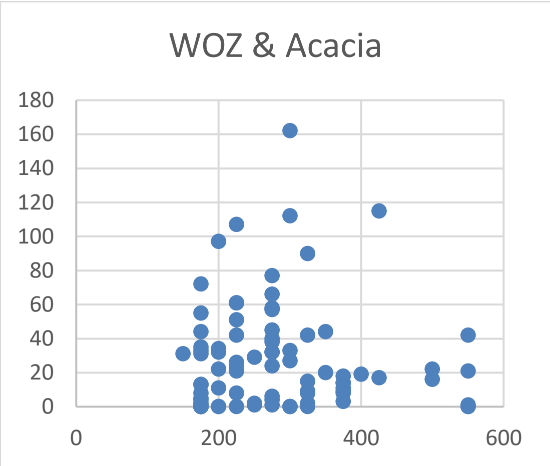


Figure 32: WOZ value & Acacia tree.

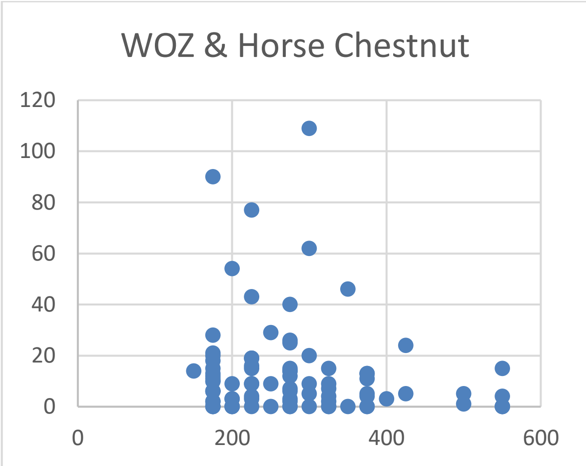


Figure 33: WOZ value & Horse Chestnut tree.

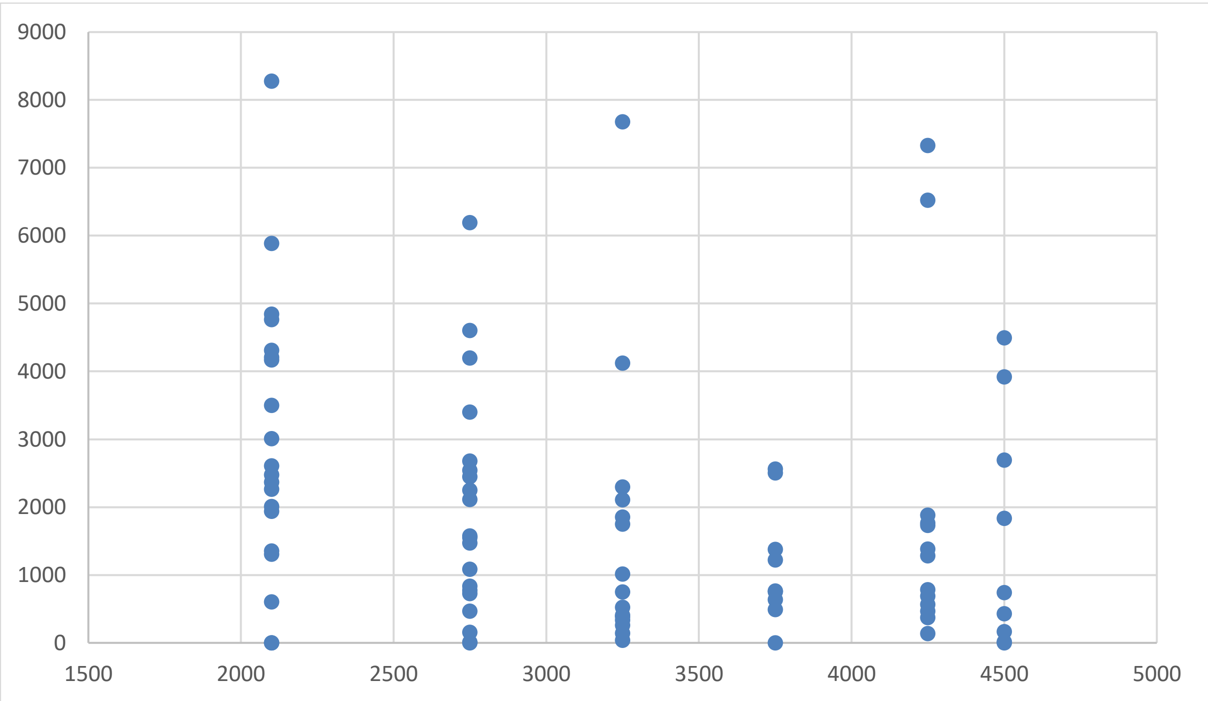


Figure 34: Income and sum of trees.