UNIVERSITY OF GOTHENBURG

DEPARTMENT OF BIOLOGICAL AND ENVIRONMENTAL SCIENCES

PERCEPTION OF URBAN TREES AND THEIR ECOSYSTEM SERVICES

Emma Dalros Sköld

Degree project for Master of Science (30 hec) with a major in Environmental Sciences

ES2500, Examination Course in Environmental Science, 30 higher education credits

Second cycle

Semester/year: Spring/Autumn 2023

Supervisor: Lasse Tarvainen & Jenny Klingberg, Dept of Biology and Environmental Sciences

Examiner: Håkan Pleijel, Dept of Biology and Environmental Sciences

UNIVERSITY OF
GOTHENBURG

Perception of urban trees and their ecosystem services

Emma Dalros Sköld

Spring 2023

UNIVERSITY OF GOTHENBURG

Department of Biological and Environmental Sciences

ES2500 - Degree Project Environmental Science (Master), 30 HEC

Supervisors: Lasse Tarvainen & Jenny Klingberg

Examiner: Håkan Pleijel

Abstract

Global urbanization is one of the most wide-ranging, irreversible, and rapid land-use changes in modern history. Natural elements, such as trees, should be incorporated into cities to produce sustainable urban environments. Urban trees can provide considerable benefits to human mental and physical well-being in addition to urban environmental quality. The value of trees for a healthy urban environment is anticipated to rise further as a result of increased urbanization and a warming climate. People are drawn to natural elements for aesthetic reasons, thus, when choosing urban trees, residential satisfaction, preferences, and their many benefits should be considered. Due to this, the aim of this thesis was to gather information about people's perceptions of urban trees and their different ecosystem services. With the intention of contributing to understanding about which type of tree people prefer in the urban environment and why.

The survey-based thesis, conducted in Gothenburg Central Station, investigates the public's preferences and attitudes towards eight urban tree types, examining which traits and ecosystem functions are of public importance and whether they vary in relation to gender. The results show that there is no difference between genders. The majority of both genders considered tall trees and a large, compact tree canopy more attractive than smaller ones. The tree types *Quercus cerris*, *Liquidambar styraciflua*, and *Betula pendula* were the top three preferred trees, with *Quercus cerris* being the most preferred due to its large size. Furthermore, the majority favoured deciduous trees over conifers.

The choice of tree images and the background may have had an impact on respondents' perception, as they were in the context of spring/summer and two of the most desired tree traits involve the tree crown's properties, which will change depending on the season. Future research should therefore focus on urban tree perception of autumn and winter trees, as well as with a different urban background.

The results of this thesis can be utilized to help urban planners, landscape architects, and other professionals better take the desires of the public into account while planning a green infrastructure. Additionally, it is important to consider whether communication strategies need to be put in place if the plantation of climate-smart trees contributes traits less desirable to the public.

Keywords: Perceptions; Tree preferences; Urban trees; Ecosystem services;

Table of content

1. Introduction

One of the largest, fastest, and most irreversible land use changes in modern history is global urbanization (Gao & O'Neill, 2020). To create a sustainable urban environment, natural components should be included in a city (Camacho-Cervantes et al., 2014). Therefore, including urban trees in cities is crucial (Potchter et al., 2006; Bowler et al., 2010; Shashua-Bar et al., 2010). Since they can supply what are known as ecosystem services (Rötzer, 2019), which can have a significant positive impact on the urban environment and its inhabitants (Willis & Petrokofsky, 2017).

In the past, urban trees only served as decorations, but they are now also acknowledged for their functions and other values (Sanesi & Chiarello 2006). Their occurrence and quantity mitigate urban heat stress (Grimm et al., 2008; Bowler et al., 2010; Shashua-Bar et al., 2010), reduce atmospheric carbon dioxide (Nowak and Dwyer, 2007), remove air pollutants (Nowak et al., 2014), provide nectar and pollen to pollinators and habitat for other wildlife species (MacGregor-Fors et al., 2011), reduce building energy use, control wind speed, noise levels, rainfall runoff, and flooding (Nowak & Dwyer, 2007). These ecosystem services provided by urban trees play a crucial role in enhancing human mental and physical well-being and aesthetic worth (Locosselli et al., 2023). Additionally, urban trees have been implied to enhance stability and familiarity, as well as contribute to the idea of a healthier and cleaner environment and residential quality (Camacho-Cervantes et al., 2014). As the climate gets warmer, the importance of trees cooling effects for a sustainable urban environment is expected to further increase (Gerstenberg & Hofmann, 2016). Thus, there is a growing importance of incorporating more urban trees (Kabisch et al., 2015), and since people are aesthetically attracted to natural features, the selection of urban trees regarding residential satisfaction, preferences, and their different advantages should be considered (Joye, 2007). Other studies have identified the potential benefits of them (Lohr et al., 2004). However, the public's perceptions are not limited to those (Roman et al., 2021), and attitudes regarding trees can differ based on a person's gender (Carmichael and McDonough, 2019).

Numerous urban tree management plans and strategies in cities all over the world take ecological and arboricultural factors into account rather than social factors (Ordóez & Duinker, 2013). It is therefore important to devote efforts to evaluating and understanding people’s perceptions of urban trees to raise awareness on how urban planners, landscape architects, and other professionals involved in the planning of a green infrastructure can better incorporate the communities' desires (Avolio et al., 2018). As the public's views have a meaningful influence on improving community identity, social infrastructure, connection to nature (Zhang et al., 2007), and nature-based human wellbeing (Oh et al., 2021). Thus, obtaining the public's perceptions is of significant value (Zhang et al., 2007). Additionally, it is important to identify whether climate-smart trees contain traits less desirable to the public, and then communication strategies need to be put in place to explain the advantages (Nohed, 2019).

1.1 Urban trees

Few urban tree studies have attempted to define what urban trees are (Randrup, 2005; Roy et al., 2012). For the purposes of this paper, an urban tree is a woody perennial plant that grows in urban areas. They often have a single stem or trunk that grows to a significant height and bears lateral branches at a height above the ground. They also frequently have a distinct crown. Thus, urban trees are any trees that grow in publicly accessible green places, such as streets and parks, individually as well as in stands, patches, or groups (Roy et al., 2012).

They can consist of both deciduous trees and coniferous trees. The leaves of most deciduous trees sprout in the spring, change colour in the fall, and fall off in the winter. Coniferous trees typically produce needles and cones rather than leaves. Generally, conifers do not change colour in the fall like deciduous trees do, and they maintain their colour throughout the winter, whereas most deciduous trees lose their leaves and turn brown. According to research based on 328 cities around the world, deciduous trees are the most common urban tree species (Yang et al., 2015).

1.2 Ecosystem services of urban trees

Ecosystem services are functions found within ecosystems that provide a variety of benefits to people and have an impact on their quality of life (Naturvårdsverket, 2014). Urban trees are known to provide several ecosystem services to urban dwellers and other organisms, including environmental, economic, mental, social, and aesthetic values (Roy et al., 2012; Gómez-Baggethun & Barton, 2013; Salmond et al., 2015). The interactions between people and the ecosystems that support us are crucial building blocks in the work of sustainable development (Bradshaw et al., 2021), as they touch on the environmental, economic, and social dimensions of sustainability (Hong, 2019). Researchers have evaluated the effects of urban trees and other green spaces on physical, mental, and social well-being using the World Health Organization's (WHO) definition of health (Nesbitt et al., 2017; van den Bosch & Ode Sang, 2017; Kondo et al., 2018; Wolf et al., 2020) as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (Sartorius, 2006). According to their findings, maintaining urban trees can significantly affect people's general health and has been linked to benefits for physical health like decreased mortality, improved attention, and behavioural changes that enhance people's physical well-being (Hartig et al., 2003; Velarde).

According to research, urban trees significantly improve the quality of the air (Isaifan & Baldauf, 2020), lower pollution concentrations (Yin et al., 2011; Fantozzi et al., 2015; Irga et al., 2015; Yli-Pelkonen et al., 2017; Viippola et al., 2018), and reduce particulate matter (PM) in the atmosphere (Yli-Pelkonen, 2017; Heshmatol Vaezin et al., 2021). A study by Tiwary et al. (2009) stated that London's 25% tree cover is estimated to remove 90.4 tons of PM10 pollution annually, resulting in a reduction of 2 deaths and 2 hospital admissions. Furthermore, the total amount of pollutant removal by urban tree cover in the United States has been observed to decrease 670,000 incidences of respiratory symptoms and 430,000 intensified asthma incidences, as well as increase school attendance by 200,000 days (Nowak et al., 2014).

Including trees in urban settings will result in more shade provision, which reduces the short-wave solar radiation reaching the ground or buildings by as much as 60–90% (Rahman et al., 2020). Research has found that the direct effect of transpiration on lowering the air temperature near a tree or below the canopy varies between 1 °C and 8 °C (Rahman et al., 2019; Georgi & Zafiriadis, 2006). A study in the U.K. observed that surfaces heated by the sun on asphalt differed in surface temperature by 12 °C from the temperature on asphalt in the shade under urban trees (Armson et al., 2012). Several studies also show associations between increased urban tree cover and improved thermal comfort, a decreased prevalence of heatstroke, and heat-related ambulance calls during high temperature events (Wolf et al., 2020).

Additionally, incorporating trees in an urban environment can give shelter from the wind and help to slow down wind speed (Jian et al., 2018), reduce urban water runoff by approximately 20% (Szota et al., 2019), and reduce noise, which have been shown to have significant health benefits, such as the alleviation of concentration issues and an improvement in sleep quality (Bodin et al., 2015). Further, Engemann et al. (2020) demonstrated the connection between children who spend more time near trees and a lower risk of suffering from various mental illnesses and mood swings.

However, urban trees are not only beneficial to people living in the city, they are also a crucial resource for many other organisms, such as various bird species and other small animals like squirrels, as they depend on trees for sustenance, shelter, and nurturing their offspring (Shackleton, 2016; Gray & van Heezik, 2016). Moreover, they provide vital floral resources for pollinating insects (Wenzel et al., 2020).

With growing urbanization and city dwellers' increased propensity to suffer from mental illness (Onelius & Sjölin, 2021; Grahn & Stigsdotter, 2010), it is essential to incorporate urban trees to promote good public health. They can impact people’s physical and mental health by reducing the risks of heat-related and air pollution-related illness and mortality, improving thermal comfort, reducing stress, noise, and mental illnesses, and providing an essential habitat and food source for city wildlife.

1.3 Tree traits important for publics preference and ecosystem services

According to research by Sander & Haight (2012), the presence of vegetation and symmetry in urban settings were seen as the most crucial elements for the public to perceive the area as visually attractive. Human wellbeing may suffer if the attractiveness of an environment is lost. To influence local land use and supply the best urban environment, it is therefore important to value people’s perceptions of certain resources, such as the tree traits of urban trees (Sander & Haight, 2012).

Tree size has been observed to be a significant factor in determining the total air pollutant uptake, with larger, dense volume of foliage and often older, trees removing considerably more pollutants from the air compared to smaller (younger) trees (Nowak et al., 2006). This correlates to the attributes of trees people find more aesthetically pleasing than others, such as dense foliage, wide branches and trunks, and a high height. That may also indicate that older trees are more preferred over younger ones, as they often possess all these attributes (Onelius & Sjölin, 2021). Research examining how tree shapes affect preferences has repeatedly demonstrated that people prefer views of large trees (Gerstenberg & Hofmann, 2016; Barron et al., 2021; Onelius & Sjölin, 2021) and prefer them in their neighbourhood or along the streets (Blicharska & Mikusiński, 2014).

Broad-canopy trees are not just more popular with the public or better for the air quality. They are also good at reducing noise. Measurements made in a large park in Gothenburg showed that the emergence of leaves on trees led to a reduction in noise levels (Klingberg et al., 2017). The size of the tree canopy has an impact on the decreased noise levels. A larger noise reduction has been observed with increases in the total area of the tree crown and mean crown height. Thus, the more tree surfaces there are (leaves, needles, and branches in the tree), the greater the noise reduction will be (Rathoure & Modi, 2019; Zhao et al., 2021). Broadleaved trees with large leaves are more effective in reducing noise than conifers (Dobson & Ryan, 2000).

Furthermore, large trees with wide canopies, in particular, also promote cooler conditions, as they reflect more solar radiation and store less energy in contrast to most artificial surfaces (e.g., asphalt or concrete), as well as reducing the long-wave radiation fluxes emitted from the cooler surfaces by the shade (Nowak et al., 2014). Camacho-Cervantes et al. (2014) revealed that people prefer shade-providing trees, and Ng et al. (2015) reported that over 80% of the respondents surveyed in Hong Kong preferred larger urban trees because they could provide shade. However, no statistically significant relationships between gender and tree preference were found (Ng et al., 2015; Camacho-Cervantes et al., 2014).

In addition to improving air quality, reducing noise levels, and providing shade, trees also provide wind shelter and can reduce wind speed. Which can help minimize the development of wind tunnels, a common occurrence among tall structures. The effectiveness of the windbreak depends on the canopy's thickness. The tree crown should not be overly dense since it is preferable to allow some wind to move through the trees rather than pushing it over the top (Jian et al., 2018). Not overly dense tree crowns may be more beneficial as windbreaks, however, as mentioned in the text above, people have been observed to find trees with dense crowns to be the most attractive (Nelson et al., 2001; Onelius & Sjölin, 2021; Gerstenberg & Hofmann, 2016), and no differences between genders have been discovered (Camacho-Cervantes et al., 2014; Onelius & Sjölin, 2021). Additionally, a complete canopy is considered more attractive compared to a damaged canopy (Nelson et al., 2001).

Unlike deciduous trees, which lose their leaves seasonally, evergreen trees are in leaf all year, thus providing year-round removal of particles (Nowak et al., 2014). However, observations indicate that people prefer deciduous trees over evergreen ones (Shackleton & Mograbi, 2020; Onelius & Sjölin, 2021). Individuals' experiences with urban trees can vary widely, and depending on their aesthetic qualities, different people are affected in different ways. According to Lyytimäki et al., (2008), a tall avenue of deciduous trees can, for example, improve the wellbeing of pedestrians while upsetting the neighbours who live nearby because the trees block their view.

The presence of urban trees is an important element for the public to perceive the area as visually attractive (Sander & Haight, 2012). Large tree size has been observed to be beneficial in total air pollutant uptake (Nowak et al., 2006), promote cooler conditions (Nowak et al., 2014), reduce noise levels (Klingberg et al., 2017), provide wind shelter, and reduce wind speed (Jian et al., 2018), as well as being preferred by the public according to several studies (Gerstenberg & Hofmann, 2016; Barron et al., 2021; Onelius & Sjölin, 2021). However, depending on the traits of urban trees, different people may have very varied experiences with them, as people are affected in different ways (Lyytimäki et al., 2008).

1.4 Negative impacts of urban trees

While urban trees offer various benefits, they may pose challenges for people in urban environments. The spread of trees can damage infrastructure and the built environment, as their root systems can break up the asphalt area surrounding them or disrupt underground cables and wires. Such damage can incur significant economic costs (Sjöman & Slagstedt, 2015). Urban trees can also have a significant negative health outcome. Their pollen release, particularly that from deciduous trees such as birch, can cause allergies (Eisenman et al., 2019). A study by Cariñanos et al. (2014) observed that during the pollination period, urban green spaces with different plants and trees have the potential to trigger an allergic reaction in around 30–40% of the world's population. Furthermore, trees that are perceived as messy and wild may generate anxiety as they may create a sense of risk for criminal encounters (Koyata et al., 2020). Studies have observed that older adults and women in particular experience insecurity to a greater extent than younger individuals and men, with women fearing violence or abuse and older individuals feeling physically weak and fragile (Onelius & Sjölin, 2021).

However, according to Maas et al. (2009), some research suggests that areas with abundant greenery might be perceived as safer by women and the elderly.

Urban trees that have dense crowns may generate more garbage when they shed their leaves compared to trees of a similar crown size but with less dense crowns (Camacho-Cervantes et al., 2014). Their fallen leaves, branches, and fruit may block the pavement, signs, or streetlights, generate maintenance expenses, and harm property, leading to problems for people (Koyata et al., 2020), and are therefore disliked by the public. However, when asked to choose liked and disliked traits of trees, research shows that residents more frequently considered attributes such as size, shade provision, and leafiness as liked traits than tree litter as a disliked trait of urban trees (Camacho-Cervantes et al., 2014). Thus, the positive benefits provided by urban trees usually overcome their negative effects (Sicard et al., 2018). However, it is important for human well-being to consider all the effects of trees on the urban environment, including the negative ones (Lyytimäki & Sipilä, 2009).

This survey-based study will therefore investigate the public's preferences and attitudes towards eight urban tree species, in particular the characteristics and ecosystem services of urban trees that are important. The influence of gender will also be explored. The observed results will then be part of a larger project regarding tolerant trees to promote sustainable cities in a changing climate, where they will be discussed from the perspective of a potential conflict between tree types that are popular with the public but less "climate smart".

1.5 Objectives

The aim of this thesis is to identify people's perceptions of urban trees and their different values, with the intention of contributing to an understanding of which type of tree people prefer in the urban environment and why.

Specific objectives are to:

1. Identify tree traits that are relevant to people's tree preferences and whether they vary in relation to gender.
2. Examine people's preferences among the selected ecosystem services provided by urban trees.
3. Investigate which selected exampled trees people perceive as the biggest contributors to the ecosystem service they prefer and why.

2. Materials and methods

2.1 Study area

This survey-based study was conducted in the central station (Figure 1) of the city Gothenburg, Sweden's second-largest city after Stockholm. It is a coastal city situated on Sweden's western coast, founded in 1621 by King Gustav II Adolf (Enhörning, 2010). The Gothenburg main station, which is made up of the Central Station, the Central House, and the Nils Ericsson terminal, is one of the city's primary transportation hubs for numerous lines and modes of transportation. Passengers arrive or depart from local buses, long-distance buses, trams, local trains and long-distance trains, taxis, and private vehicles. The location is often crowded and packed with local and national residents as well as internationals who are either arriving from elsewhere or waiting for their transportation. Additionally, there are numerous eateries, stores, and service facilities inside the station buildings (Qamhieh, 2012).

Figure 1. Inside of Gothenburg Central Station where the survey collection occurred. Photograph taken by Emma Dalros Sköld.

2.2 Stimulus material

Images (Figure 2) of eight different tree species (for scientific, common species names and characteristics, see Table 1) were generated using Adobe Photoshop software (version 15.2.2, Adobe Systems Inc., San Jose, CA, U.S.A.). Photoshop was utilized to crop and combine pictures of the different tree species with a background picture of an urban environment next to Gothenburg Central Station. The generated pictures were developed on A4 paper size (21 cm by 29 cm), with four tree images on each paper. The eight selected tree species can be found in both hot and cold temperate climates. Both deciduous trees and conifers were included. However, fruit trees and shrubs were excluded. All trees are shown against the same urban background from the same angle.

Figure 2. The eight different tree types A–H used in this study of people's preferences. The photographs of the eight different tree species (Table 1) were provided by Henrik Sjöman, and the background photograph was taken by Emma Dalros Sköld.

Table 1. The eight tree species depicted A-H in scientific and common names and their characteristics.

ID	*Scientific* (Latin) name	Common name	Characteristics
A.	*Liquidambar styraciflua*	Sweet Gum	Deciduous, tall tree, colourful complex shaped leaves
B.	*Acer platanoides*	Norway maple	Deciduous, compact, and dense tree canopy
C.	*Pinus nigra*	Austrian pine	Conifer, tall tree, sparse tree canopy, long needles
D.	*Betula pendula*	Silver birch	Deciduous, tall tree, large compact tree canopy
E.	*Tilia cordata*	Littleleaf linden	Deciduous, short tree, small tree canopy
F.	*Picea abies*	Norway spruce	Conifer, compact tree canopy, short needles
G.	*Quercus cerris*	Turkey Oak	Deciduous, tall tree, large compact tree canopy
H.	*Acer rubrum*	Red Maple	Deciduous, short tree, small tree canopy

2.3 Design of the survey

The survey was designed in Microsoft Forms and consisted of a total of 10 questions (Appendix A). The survey was written in Swedish according to guidelines created by Ejlertsson (2019) and Trost (2012) regarding the design of questionnaires as well as important aspects to consider when formulating questions. Based on that, a standardized questionnaire was created. This means that all respondents had to answer the same questions with the same answer options. To allow for comparisons between the replies and to make them generalizable, the questions were mainly closed questions, in accordance with recommendations made by Trost (2012). However, according to Bryman (2018), closed questions may overlook a significant amount of spontaneity in the responses. Certain questions also featured an open answer option in order to prevent rejecting potential answers that the responder did not find to be included in the provided answer alternatives as well as to document more details. Additionally, neither the survey's questions nor its answer alternatives were purposefully misleading or contained difficult technical terminology. Instead, they were created to prevent influencing the respondents. The answer options for the choice-based questions were randomized. According to Stantcheva (2022), this is the best way to avoid bias.

The respondent's age and gender were asked about in the initial background questions. The reason for requesting this data was to be able to discover any patterns in the results. To identify any flaws or issues with the question wording or structure, a small test group got to look at the survey before it was distributed.

When deciding the question options for this study, the purpose of each question was carefully thought through. Since each question asked in this survey will obtain a different response from each participant, the information this study wants to obtain from the respondents was considered. The questions in the survey consisted of seven-point Likert scales. A seven-point Likert scale was used, as according to Taherdoost (2019), the most reliable test-retest range is between a 7 and 10 response scale. Furthermore, to collect and analyse data using a Likert scale, the seven-point scale is the most accurate variety. As it provides a better representation of the respondent's genuine opinion. The tree images were used in two of the questions to make it clear which kinds of trees the question and answer choices related to. Other questions in the survey consisted of multiple-choice questions and ranking questions, as well as one open question.

2.4 Data collection

The data was collected through in-person field survey studies during six weekdays at the end of March 2023. During two of the sampling days, data was collected from 10 a.m. to 12 p.m., two other days from 13:30 to 16.30 p.m., and the additional two days from 17:30 to 19:30 p.m.

The participants were drawn from the general population visiting Gothenburg Central Station on those days. The participants were asked to scan a QR code using their mobile phones to access the survey. They were also handed the eight tree images for a better perception of the trees, as one task from the survey was to rank them based on perceived attractiveness. The survey took about 7–9 minutes to complete. According to Fanning (2005), surveys under 12 minutes are preferred, although 10 minutes or less is preferable. Often, the longer the survey, the higher the dropout rate.

2.5 Participants

There were 104 people contributing to the survey. The survey's target population was those who were 18 years of age or older and who were at Gothenburg's Central Station during the collection of data. The age distribution among the respondents consisted of 43% between 18 and 35 years old, which was the largest proportion, followed by 37% between 36 and 55 years and 20% between 56 and > 65 years. Most respondents identified themselves as women (62%), and the remaining respondents identified themselves as men (38%). The study does not process sensitive personal data, all respondents participated voluntarily and gave their approval for the use of the data, which were obtained anonymously.

2.6 Statistical analysis

The web survey responses were automatically collected in Microsoft Forms and downloaded to an Excel file. With the use of this function, the possibility of inaccurate response entries was removed (Bryman, 2018). Excel (version 2303, Excel Industries Ltd., Redmond, WA, U.S.A.) was used to assemble and present the survey's quantitative data in a variety of displays. The standard deviation and independent sample t-test were used for some selected questions to test if there were any significant correlations and/or differences. The closed questions were also analysed using the sample group's (gender) mean and percentages. To summarize the data from the answers to the one open question in the survey, they were transcribed and organized into various categories. Then similar categories were combined to find patterns.

3. Results

3.1 Tree preference

The overall preference evaluation median between the two genders indicates Turkey oak being voted as the most attractive tree type in an urban environment (women 6.8, men 7.0), followed by Sweet gum (women 6.6, men 6.5), and Silver birch (women 6.1, men 6.2). Norway spruce was seen as the less attractive tree type among both genders (women 1.8, men 1.7) (Figure 3).

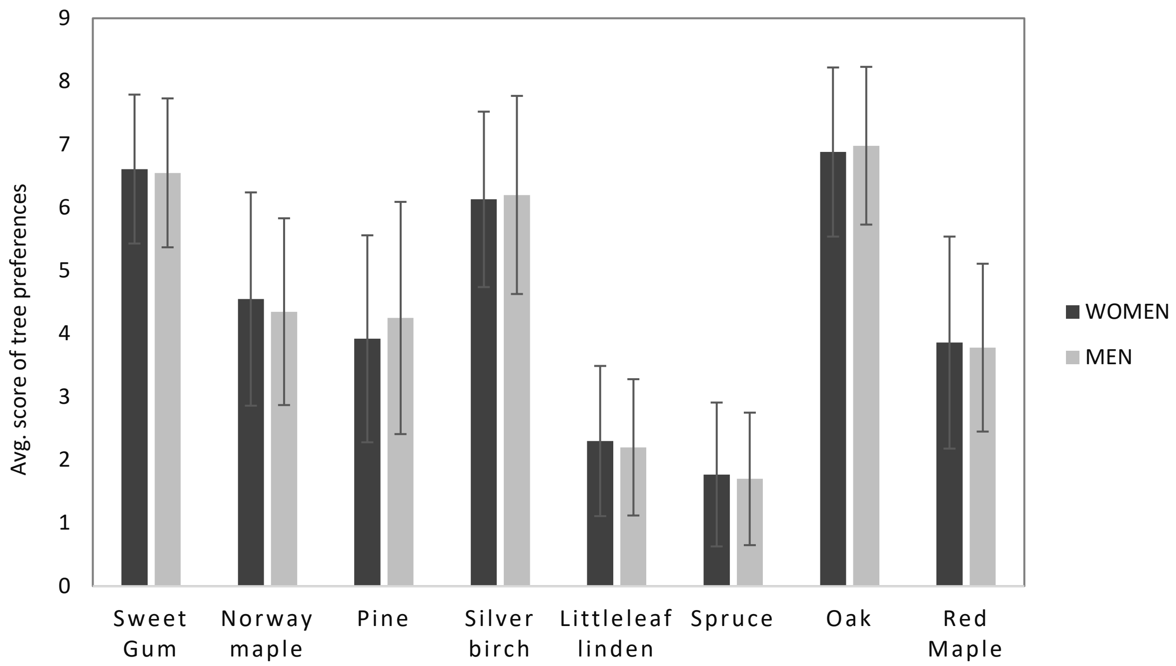

Figure 3. The tree types (A – H) the respondents think are most attractive in a city environment. The average score of each tree is shown, divided by gender, where the number 8 indicates "Most attractive", and the number 1 "Less attractive". Question 3 in the survey.

In addition to the fact that no specific differences were seen between the genders regarding tree type preferences (Figure 3), men and women also preferred similar tree characteristics (Figure 4). Both genders considered a large tree canopy (25% of the men and 23.5% of the women) to be the most attractive feature among urban trees. Followed by a compact tree canopy (22% of the men and 19.5% of the women), then a tall tree (13.5% of the men and 15.5% of the women). The least selected characteristic among both genders was for a tree to have long needles (0% of the men and 1% of the women). These results indicate that deciduous trees are preferred over conifers.

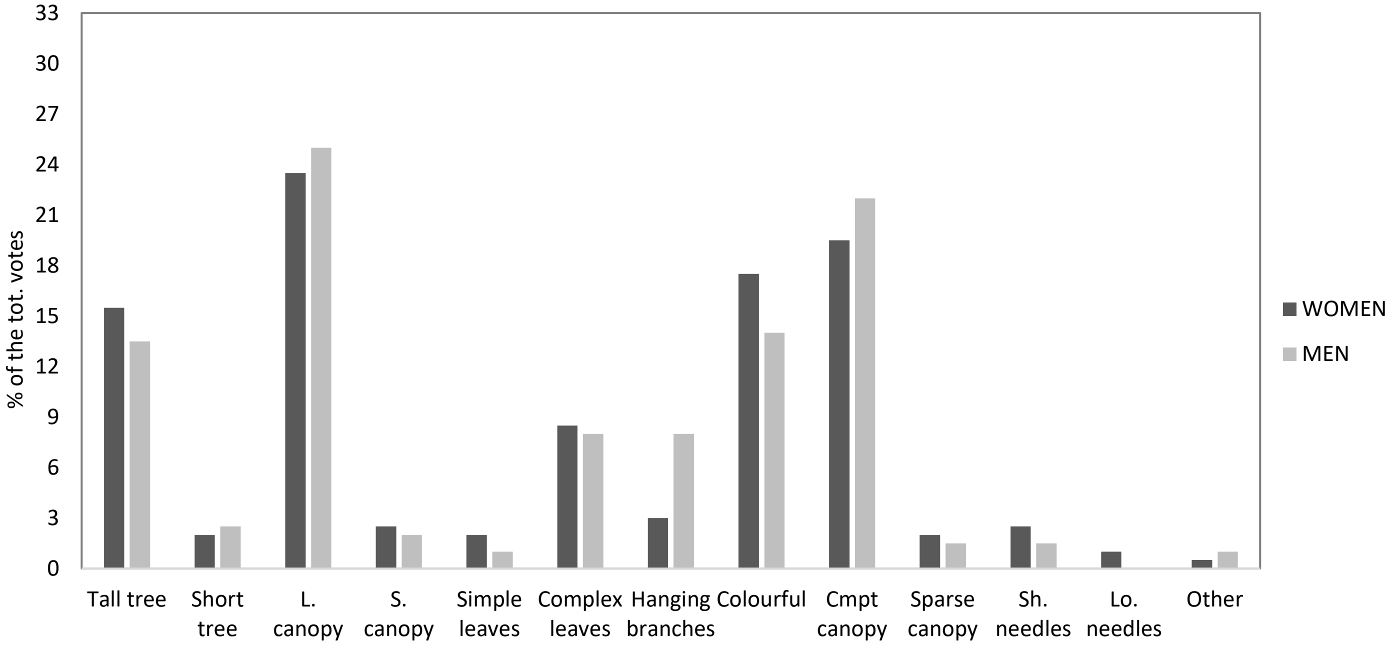

Figure 4. The percentage of tree characteristics the respondents think are most attractive in an urban environment, divided by gender. Question 4 in the survey; see Appendix B. for the full list of the characteristics asked in the survey.

3.2 Perceived experiences of urban trees

The impact of gender on the perceived experience shows that women generally, to a small degree, perceive an urban environment with trees close to buildings as more beautiful, safe, pleasing, and stress-relieving compared to men (Figure 5). However, the independent sample t-tests showed that there was no significant difference between the genders perceived experiences of urban trees making the urban environment beautiful (M = 5.49, SD = 1.64 women and M = 5.30, SD = 1.69 men) p = 0.78, safe (M = 4.18, SD = 1.37 women and M = 3.75, SD = 1.46 men) p = 0.13, pleasant (M = 5.17, SD = 1.66 women and M = 4.97, SD = 1.57 men) p = 0.55, or stress-relieving (M = 4.70, SD = 1.58 women and M = 4.50, SD = 1.70 men) p = 0.51. Specifically, the results indicate that there is no specific difference between genders experiences of beauty, safety, pleasantness, and stress-relieving effects from urban trees near buildings.

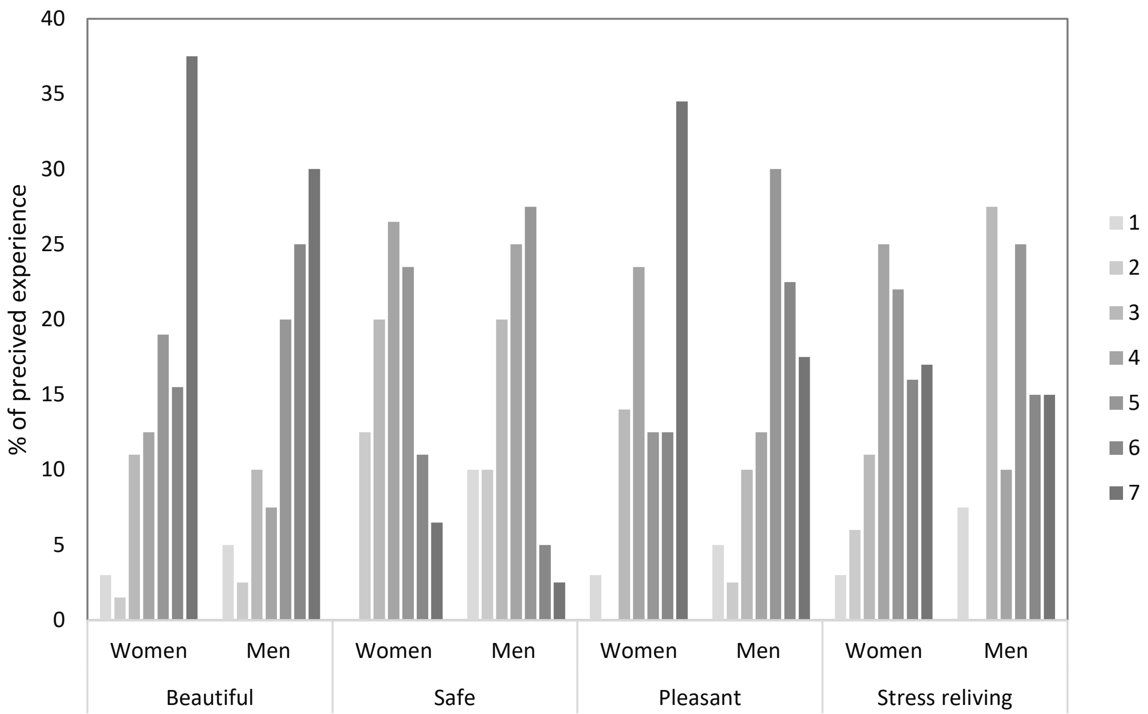

Figure 5. Percentage of the perceived experience with trees close to buildings, divided by gender, from 1 = "Strongly disagree" to 7 = "Strongly agree". Question 6 in the survey.

3.3 Preferred urban tree benefits

Making the environment more beautiful was ranked as the most significant benefit of urban trees (26.5% women, 24% men), followed by urban trees ability to filter particles and clean the air from impurities (17% women, 16% men). Men rated the ability of trees to absorb carbon dioxide as equally significant as the ability to filter air (16%), whereas women considered trees ability to contribute to a more pleasing environment as the third most important benefit (14.5%) (Figure 6). This ability was not as highly valued by men as it was by women, and it also had the biggest gap in scores between the sexes (6.5% difference). Trees' ability to reduce the risk of flooding was seen as the least important benefit for both genders.

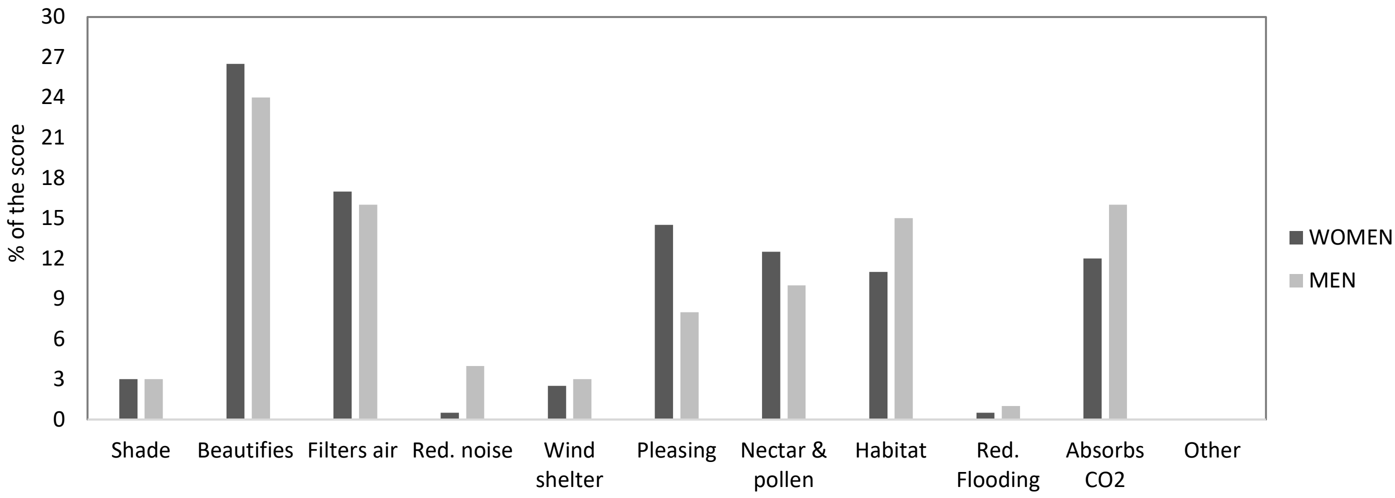

Figure 6. Percentage of urban tree benefits the respondents think are the most important. Divided by gender. Question 7 in the survey; see Appendix C. for the full list of the whole sentences of benefits asked in the survey.

When respondents were asked to choose the tree they thought was most important in contributing to ecosystem services, the most common answer among the genders was G. Turkey oak (58% women and 62.5% men), followed by D. Silver birch, which received equally many votes from both genders (25% and 25%) (Table 2). The most common reason for considering Turkey oak as the largest ecosystem contributor among the 62 respondents voting for it was due to its large size: 95% of the women and 84% of the men (Table 3).

Table 2. The respondents vote on which tree they think is most beneficial in contributing to ecosystem services. Question 8 in the survey.

Tree types	Total score (%)	Women (%)	Men (%)
A. Sweet Gum	8.5	9.5	7.5
B. Norway Maple	2	3	
C. Austrian Pine			
D. Silver Birch	25	25	25
E. Littleleaf Linden	1		2.5
F. Norway Spruce	1	1.5	
G. Turkey Oak	59.5	58	62.5
H. Red Maple	1	1.5	
Do not know	2	1.5	2.5

Table 3. The reasons why the respondents voted for Tree G. (Turkey Oak) as the most beneficial tree in contributing to ecosystem services. Total score = the 62 respondents who voted for G. (Turkey Oak). Question 9 in the survey.

Why Turkey Oak	Total score (%)	Women (%)	Men (%)
Large tree	90.3	95	84
Good habitat for animals	1.5		4
Beautiful	3.2	2.5	4
Do not know	5	2.5	8

3.4 Negative aspects

Finally, when respondents were asked to come up with (if they considered urban trees to have one) any negative aspects they thought urban trees might have, the most common reply was to leave the comment area blank, indicating "no negative aspects/no comment", and the most written reply was that "urban trees litter" (Figure 7). Fewer women (33%) than men (38%) noted negative aspects. Women (5%) considered trees contributing to an unsafe environment to a slightly greater extent than men (2.5%).

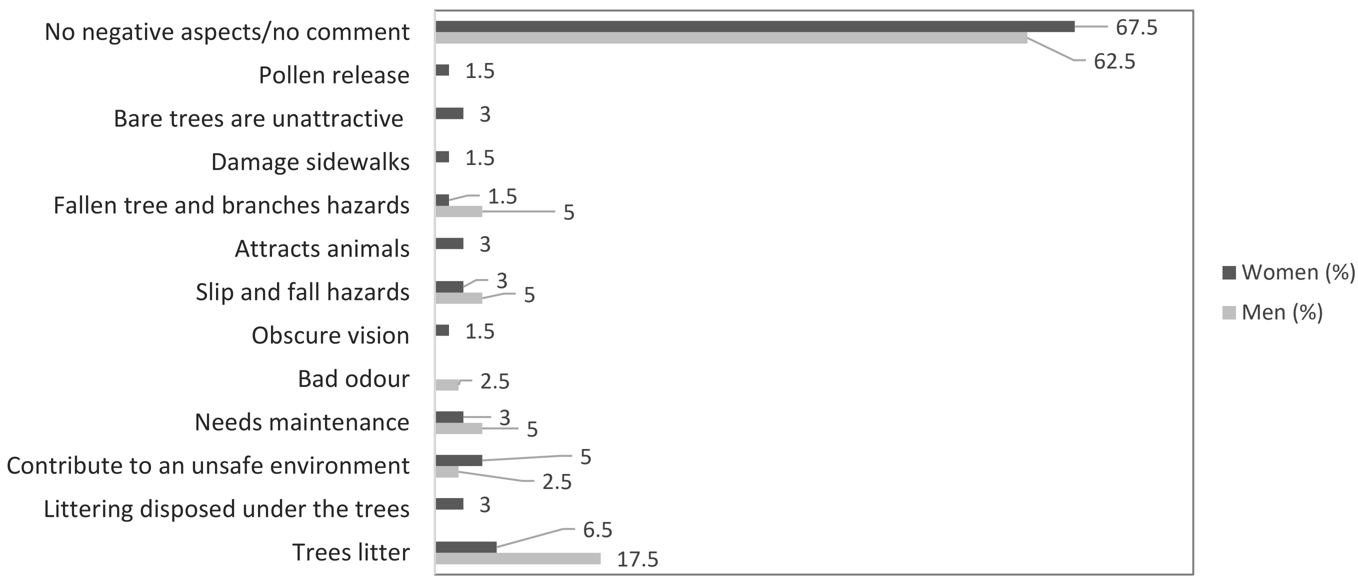

Figure 7. Percentage of the negative aspects the respondents could think of when asked if they perceived any. Divided by gender. Question 10 in the survey.

4. Discussion

This study contributes to an understanding of the general public's perception of urban trees and their ecosystem services to raise awareness on how urban planners, landscape architects, and other professionals in the planning of a green infrastructure can better incorporate the communities' desires. This was achieved through a survey investigation of urban dwellers perceived attractiveness, experiences, and benefits of urban trees.

4.1 Urban tree type preference

The results of this study support several other studies (Nowak et al., 2006; Camacho-Cervantes et al., 2014; Gerstenberg & Hofmann, 2016; Onelius & Sjölin, 2021) suggestions that large trees and a broad, compact tree canopy are more aesthetically pleasing than smaller ones. The Turkey oak, Sweet gum, and Silver birch were the top three favoured trees, with the Turkey oak being the most preferred (Figure 3). The characteristics that respondents found most attractive were also those that were especially associated with deciduous trees, such as a compact, large tree canopy or colourful leaves (Figure 4). The preference assessment gave the lowest grades to Norway spruce (Figure 3). There were no clear differences between the genders in their choices of preferred tree type or tree characteristics that were most and less attractive in urban environments. These findings are similar to those by Gerstenberg & Hofmann (2016) and Onelius & Sjölin (2021), who discovered that the largest and densely leafed trees are perceived as the most appealing. Tree crowns with high density may appear to be more complete. Gestalt grouping principles state that the human visual system prefers to see closed or finished forms (Lin, 2004). Thus, dense, complete crown shapes should be easier to notice and understand, which could increase the desire for these crowns. Additionally, the preference for broad, compact tree canopies is consistent with Orians's savannah hypothesis, which implies that humans prefer large crown sizes relative to trunk height (Hartmann, 2013). Conifer characteristics such as long and short needles were rated as less attractive (Figure 4). This might be due to their different shapes from the typical tree shapes found in the lush African savannah ecosystems, which seem to be the most attractive.

4.2 Perceived experiences of urban trees

Among both genders, the most highly regarded experience perceived by urban trees close to buildings was their contribution to making the environment beautiful, followed by their ability to make the environment more pleasing (Figure 5). These findings are consistent with research reported by Sander & Haight (2012), who observed that the presence of urban trees in urban environments is seen as one of the most important elements affecting the public's perception of the setting as attractive. According to Donovan & Butry (2010) and Joye et al., (2010), such an improvement in visual appeal may also have a positive impact on the increased economic value of the area.

The Stress Reduction Theory (SRT), put forth by Ulrich et al. (Luo & Jiang, 2022), states that exposure to the natural environment is correlated with positive feelings that lessen mental stress. As vegetation can relieve stress, while artificial surroundings without any greenery can increase mental stress (Luo, & Jiang, 2022). Furthermore, in several studies (such as Van den Berg et al., 2014; Tyrväinen et al., 2014), urban settings with vegetation have been found to reduce stress more than urban areas without any vegetation. Gender differences have not been seen in any of these studies. Correlating to the result of this study, both men and women regarded urban trees as stress-relieving. On a scale of 1 = "Strongly disagree" to 7 = "Strongly agree," the mean value of urban trees contributing to the environment being stress-relieving was 4.5 for men and 4.7 for women. Additionally, the results of both genders in this study showed that urban trees just slightly increase perceived environmental safety. As some trees are viewed as messy and wild, they might provide a feeling of an unsafe environment and may create a sense of a higher risk of criminal encounters (Koyata et al., 2020), which may be one explanation why urban trees only slightly contribute to the urban setting being perceived as safer.

4.3 Favoured urban tree benefits and tree viewed as most beneficial contributor

When asked what the most important benefit of urban trees was, both men and women most frequently perceived it as their contribution to making the environment more beautiful (Figure 6). This, as previously noted, was also regarded as the highest-ranked perceived experience. Following that, the second most important benefit observed was urban trees involvement in filtering particles and cleaning the air from pollution. When investigating which of the selected tree species the respondents thought was the biggest contributor to the ecosystem service they preferred, more than 59% of the respondents thought that the tree type Turkey oak contributed the most ecosystem services, followed by Silver birch (Table 2), which is similar to the trees voted as the most attractive once (Turkey oak was voted the most and Silver birch was the third most attractive tree type) (Figure 3). The majority of the respondents selected Turkey oak due to its large size (Table 3). This is in line with other studies that show larger trees and a larger, denser volume of foliage are not only beneficial for people's perceived appeal, but they have also been observed to be a significant factor in determining the total air pollutant uptake, removing significantly more pollutants from the air compared to smaller trees (Nowak et al., 2006). As well as contributing to ecosystem services like species diversity for cultural ecosystem services as habitat for more birds and bees, which also contributes to the setting being more appreciated as the sound from the birds makes people feel at ease. Furthermore, it is also beneficial for various regulatory ecosystem services, such as wind protection, cooling through both transpiration and shading, and runoff control, which are also shown to benefit from more tree foliage (Andersson-Sköld et al., 2018). Consequently, the qualities of a tree that are regarded as attractive may also be related to how well the tree filters air, provides habitat for animals, provides protection from the wind, cools, and reduces runoff.

Although the decrease in noise from urban trees has been demonstrated to have considerable health advantages, including the enhancement of sleep quality and the easing of attention problems (Bodin et al., 2015), this study's participants did not rank noise reduction as one of urban trees' more important benefits.

4.4 Negative aspects associated with urban trees

In the open question where the participants could write down any possible perceived negative aspects of urban trees, over 60% of respondents said there were no negative elements of urban trees or that they were unable to think of any (Figure 7). According to Sicard et al. (2018), studies have found that people perceive the positive benefits provided by urban trees as outweighing any negative effects. However, the fact that trees "litter", "generate accidents", "are unattractive when bare", or "need maintenance" was the part that people disliked the most. These findings are consistent with research reported by Camacho-Cervantes et al., (2014) and Koyata et al. (2020), who noted that undesirable characteristics of urban trees, such as tree littering, maintenance costs, the potential for injury, and the potential for being messy and wild, might cause issues for people. The respondents who thought that trees were connected to damages noted that "when the tree is poorly managed" or "when the leaves fall and are left on the ground," they blamed the issue on "lack of maintenance." This finding highlights the significance of management practices like leaf raking and trimming, which may influence how people view trees in urban environments.

4.5 The methodology of the survey study

Using a quantitative survey study as a method has both advantages and disadvantages. One of the advantages is that it is a comparatively simple method for gathering data that can then be analysed in several ways, making it possible to generalize the findings from a smaller group to a larger one. However, some disadvantages of survey studies include the fact that it is not possible to ask follow-up questions to the respondents or verify that they provided honest and thoroughly considered responses. Also, the number of respondents who are willing to participate may be quite low. According to Ejlertsson (2019), people generally become less and less inclined to feel the need to respond to surveys. For this study, one reason may be that the people asked to participate were limited to the collection point (Gothenburg Central Station), where they may have been on the go and not had time to fill in the survey.
The fact that more women participated in the survey may be because they were more frequently asked or because the majority of people visiting Gothenburg Central Station were women. Furthermore, according to previous research, women are more likely to take part in surveys compared to men (Smith, 2008).

Multiple-choice questions, ranking questions, an open question, and seven-point Likert scales with corresponding answer possibilities were the answer options in the survey. The ranking question was used for ranking the most attractive to less attractive tree type instead of a Likert scale. Thus, the respondents were then "forced" to rank the trees according to their attractiveness instead of evaluating each tree individually, which may increase the likelihood that each tree can be rated similarly. However, using the ranking approach prevents statistical analysis from being performed. Furthermore, a seven-point Likert scale was used, as it, according to Taherdoost (2019), is the most reliable test-retest range. It provides a better representation of the respondent's genuine opinion. However, this made it a little more challenging for respondents to complete the survey on a mobile device because the scale's seven points were not displayed on the entire screen, and participants had to scroll sideways to choose the scale they wanted to use.

4.6 Potential conflict of preferred tree traits and climate-smart trees

As mentioned earlier, the findings of this study and several others demonstrate that people prefer large trees with a broad and dense canopy, which are also good providers of ecosystem services (Nowak et al., 2006; Camacho-Cervantes et al., 2014; Gerstenberg & Hofmann, 2016; Onelius & Sjölin, 2021). However, compared to various smaller trees, many larger trees, such as birches, require more water (Sjöman et al. 2015). Therefore, the most preferred trees may pose a potential problem from a climatic perspective since they may cause water shortages as places become drier (Zastrow, 2019). The amount of water a tree absorbs varies between different tree species by up to 50%, and larger trees generally require more water (Bjerenius, 2019). According to ecologist Shixiong Cao, considering water shortages in a changing climate is very important (Zastrow, 2019). Thus, the most preferred tree traits and tree types from this study as well as in several others (Nowak et al., 2006; Camacho-Cervantes et al., 2014; Gerstenberg & Hofmann, 2016; Onelius & Sjölin, 2021) might not be the best choice when selecting the most climate-smart tree species considering water consumption. As opposed to this, Yang et al. (2019) argue that large trees could improve the water-holding capacities of soils, litter, and canopy interception and may have higher water conservation functions than smaller and younger trees. However, if urban trees that are beneficial from a climate perspective but not preferred by the public are being planted in urban environments, communication efforts should be implemented (Nohed, 2019).

4.7 Limitations and future studies

The external validity of the study is one of its limitations. Over the course of a tree's lifetime and annual cycle, its appearance changes. Given that the tree images are seen in the context of spring and summer, the background and tree photographs that were chosen for this study can have influenced the respondents' decision-making. Two of the most desired tree traits have to do with the tree crown's properties, which will change depending on the season, especially for deciduous trees. Thus, if they are leafless in late autumn and winter, their preference over conifers could disappear or reverse. As the response to the survey was sampled in late March, the results of this study may not be similar if the survey questions were asked in December. Future research focusing on urban tree perception of autumn and winter trees, as well as in a different urban setting, would therefore be interesting. Not finding statistical differences across genders could be since the majority of the respondents identified as women or to the total sample size. Thus, as a complement to this study, further studies should collect data from a larger sample size of people with a more balanced distribution of men and women regarding the perception of urban trees in Gothenburg or other cities.

5. Conclusion

The purpose of this study was to investigate public attitudes toward urban trees. Most respondents had positive perceptions of them. According to the findings of this survey study and other research on preferred tree characteristics (Nowak et al., 2006; Camacho-Cervantes et al., 2014; Gerstenberg & Hofmann, 2016; Onelius & Sjölin, 2021), the majority of respondents believed that tall trees, and large, compact tree canopies were the most attractive tree traits in urban environments. The Turkey oak, followed by Sweet gum and Silver birch, were the most preferred tree type. The majority favoured deciduous trees over conifers, especially those with wide, dense canopies. There were no gender differences regarding which tree characteristics and tree types the respondents found most or less attractive in urban environments.

The most perceived benefit of urban trees, according to both men and women, was that they contribute to a more beautiful environment. Followed by their ability to filter particles and clean the air from pollution. More than 59% of respondents said that the tree type Turkey oak was the biggest contributor to the ecosystem services they preferred. With the majority of respondents stating that it is because of its large size.

The findings presented in this thesis can be used by urban planners, landscape architects, and other professionals planning a green infrastructure to better incorporate the communities' desires. As well as noticing if implementation of communication efforts is needed in case the plantation of climate-smart trees is perceived as less desirable by the public.

Future studies should focus on urban tree perceptions of autumn and winter trees and on how people perceive trees in other urban contexts. As well as collect data from a larger sample size of people with a more balanced distribution of men and women.

6. Acknowledgement

First and foremost, I want to express my gratitude to my supervisor, Lasse Tarvainen, and my co-supervisor, Jenny Klingberg, for their encouragement, helpful criticism, and insightful remarks during the past few months.

Thank you, Henrik Sjöman, for providing me with your photographs of various trees.

I also want to say thank you to my examiner, Håkan Pleijel. I appreciate your time spent examining this thesis.

Finally, I would like to give a big thank you to my family and friends for their support, and especially to Jack Thomas for all his encouraging remarks as I wrote this thesis.

7. References

Andersson-Sköld, Y., Klingberg, J., Gunnarsson, B., Cullinane, K., Gustafsson, I., Hedblom, M., ... & Thorsson, S. (2018). A framework for assessing urban greenery's effects and valuing its ecosystem services. *Journal of Environmental Management*, *205*, 274-285. Doi: https://doi.org/10.1016/j.jenvman.2017.09.071

Armson, D., Stringer, P., & Ennos, A. R. (2012). The effect of tree shade and grass on surface and globe temperatures in an urban area. *Urban Forestry & Urban Greening*, *11*(3), 245-255. Doi: https://doi.org/10.1016/j.ufug.2012.05.002

Avolio, M. L., Pataki, D. E., Trammell, T. L., & Endter-Wada, J. (2018). Biodiverse cities: the nursery industry, homeowners, and neighborhood differences drive urban tree composition. *Ecological Monographs*, *88*(2), 259-276. Doi: https://doi.org/10.1002/ecm.1290

Barron, S., Sheppard, S., Kozak, R., Dunster, K., Dave, K., Sun, D., & Rayner, J. (2021). What do they like about trees? Adding local voices to urban forest design and planning. *Trees, Forests and People*, *5*, 100116. Doi: https://doi.org/10.1016/j.tfp.2021.100116

Bjerenius, S. (2019). Ranking av ekosystemtjänster kopplade till urbana träd: En avgränsad metodstudie i Skövde. Doi: urn:nbn:se:his:diva-17662

Blicharska, M., & Mikusiński, G. (2014). Incorporating social and cultural significance of large old trees in conservation policy. *Conservation Biology*, *28*(6), 1558-1567. Doi: https://doi.org/10.1111/cobi.12341

Bodin, T., Björk, J., Ardö, J., & Albin, M. (2015). Annoyance, sleep and concentration problems due to combined traffic noise and the benefit of quiet side. *International Journal of Environmental Research and Public Health*, *12*(2), 1612-1628. Doi: https://doi.org/10.3390/ijerph120201612

Bowler, D.E., Buyung-Ali, L., Knight, T.M., Pullin, A.S., (2010). Urban greening to cool towns and cities: a systematic review of the empirical evidence. *Landsc. Urban Plan*. 97 (3), 147–155. Doi: http://dx.doi.org/10.1016/j.landurbplan.2010.05.006

Bradshaw, C. J., Ehrlich, P. R., Beattie, A., Ceballos, G., Crist, E., Diamond, J., ... & Blumstein, D. T. (2021). Underestimating the challenges of avoiding a ghastly future. *Frontiers in Conservation Science*, *1*, 9. Doi: https://doi.org/10.3389/fcosc.2020.615419

Bryman, A. (2018). Samhällsvetenskapliga metoder (Tredje upplagan). Liber AB: Stockholm

Camacho-Cervantes, M., Schondube, J. E., Castillo, A., & MacGregor-Fors, I. (2014). How do people perceive urban trees? Assessing likes and dislikes in relation to the trees of a city. *Urban Ecosystems*, *17*, 761-773. Doi: https://doi.org/10.1007/s11252-014-0343-6

Carmichael, C. E., & McDonough, M. H. (2019). Community stories: Explaining resistance to street tree-planting programs in Detroit, Michigan, USA. *Society & Natural Resources*, *32*(5), 588-605. Doi: https://doi.org/10.1080/08941920.2018.1550229

Cariñanos, P., Casares-Porcel, M., & Quesada-Rubio, J. M. (2014). Estimating the allergenic potential of urban green spaces: A case-study in Granada, Spain. *Landscape and Urban Planning*, *123*, 134-144. Doi: https://doi.org/10.1016/j.landurbplan.2013.12.009

Dobson, M., & Ryan, J. (2000). *Trees and shrubs for noise control*. Arboricultural Advisory and Information Service. P 3-5.

Engemann, K., Svenning, J. C., Arge, L., Brandt, J., Erikstrup, C., Geels, C., ... & Pedersen, C. B. (2020). Associations between growing up in natural environments and subsequent psychiatric disorders in Denmark. *Environmental Research*, 188, 109788. Doi: https://doi.org/10.1016/j.envres.2020.109788

Enhörning, G. (2010). Göteborg, Sweden. *Cities*, *27*(3), 182–194. Doi: https://doi.org/10.1016/j.cities.2009.11.001

Eisenman, T. S., Churkina, G., Jariwala, S. P., Kumar, P., Lovasi, G. S., Pataki, D. E., ... & Whitlow, T. H. (2019). Urban trees, air quality, and asthma: an interdisciplinary review. *Landscape and Urban Planning*, 187, 47-59. Doi: https://doi.org/10.1016/j.landurbplan.2019.02.010

Ejlertsson, G. (2019). Enkäten i praktiken - En handbok i enkätmetodik (4:1. uppl.). Lund: Studentlitteratur

Fanning, E. (2005). Formatting a paper-based survey questionnaire: Best practices. *Practical Assessment, Research, and Evaluation*, *10*(1), 12. Doi: https://doi.org/10.7275/s84t-8a63

Fantozzi, F., Monaci, F., Blanusa, T., & Bargagli, R. (2015). Spatio-temporal variations of ozone and nitrogen dioxide concentrations under urban trees and in a nearby open area. *Urban Climate*, *12*, 119-127. Doi: https://doi.org/10.1016/j.uclim.2015.02.001

Gao, J., & O'Neill, B. C. (2020). Mapping global urban land for the 21st century with data-driven simulations and Shared Socioeconomic Pathways. *Nature Communications*, *11*(1), 2302. Doi: https://doi.org/10.1038/s41467-020-15788-7

Georgi, N. J., & Zafiriadis, K. (2006). The impact of park trees on microclimate in urban areas. *Urban Ecosystems*, *9*, 195-209. Doi: https://doi.org/10.1007/s11252-006-8590-9

Gerstenberg, T., & Hofmann, M. (2016). Perception and preference of trees: A psychological contribution to tree species selection in urban areas. *Urban Forestry & Urban Greening*, *15*, 103-111. Doi: https://doi.org/10.1016/j.ufug.2015.12.004

Gómez-Baggethun, E., & Barton, D. N. (2013). Classifying and valuing ecosystem services for urban planning. *Ecological Economics*, *86*, 235-245. Doi: https://doi.org/10.1016/j.ecolecon.2012.08.019

Grahn, P., & Stigsdotter, U. K. (2010). The relation between perceived sensory dimensions of urban green space and stress restoration. Landscape and urban planning, 94(3-4), 264-275. Doi: 10.1016/j.landurbplan.2009.10.01

Gray, E. R., & van Heezik, Y. (2016). Exotic trees can sustain native birds in urban woodlands. *Urban Ecosystems*, *19*, 315-329. Doi: https://doi.org/10.1007/s11252-015-0493-1

Grimm, N. B., Foster, D., Groffman, P., Grove, J. M., Hopkinson, C. S., Nadelhoffer, K. J., ... & Peters, D. P. (2008). The changing landscape: ecosystem responses to urbanization and pollution across climatic and societal gradients. *Frontiers in Ecology and the Environment*, *6*(5), 264-272. Doi: https://doi.org/10.1890/070147

Hartmann, P., & Apaolaza-Ibáñez, V. (2013). Desert or rain: Standardisation of green advertising versus adaptation to the target audience's natural environment. *European Journal of Marketing*, *47*(5/6), 917-933. Doi: https://doi.org/10.1108/03090561311308091

Hartig, T., Evans, G. W., Jamner, L. D., Davis, D. S., & Gärling, T. (2003). Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology*, *23*(2), 109-123. Doi: https://doi.org/10.1016/S0272-4944(02)00109-3

Heshmatol Vaezin, S. M., Juybari, M. M., Daei, A., Avatefi Hemmat, M., Shirvany, A., Tallis, M. J., Satoshi Hirabayashi, Mazaher Moeinaddini, Amir Hossein Hamidian, Seyed Mohammad Moein Sadeghi & Pypker, T. G. (2021). The effectiveness of urban trees in reducing airborne particulate matter by dry deposition in Tehran, Iran. *Environmental Monitoring and Assessment*, *193*, 1-14. Doi: https://doi.org/10.1007/s10661-021-09616-8

Hong, J., Alzaman, C., Diabat, A., & Bulgak, A. (2019). Sustainability dimensions and PM 2.5 in supply chain logistics. *Annals of Operations Research*, *275*, 339-366. Doi: https://doi.org/10.1007/s10479-018-3077-7

Irga, P. J., Burchett, M. D., & Torpy, F. R. (2015). Does urban forestry have a quantitative effect on ambient air quality in an urban environment? *Atmospheric Environment*, *120*, 173-181. Doi: https://doi.org/10.1016/j.atmosenv.2015.08.050

Isaifan, R. J., & Baldauf, R. W. (2020). Estimating economic and environmental benefits of urban trees in desert regions. *Frontiers in Ecology and Evolution*, *8*, 16. Doi: https://doi.org/10.3389/fevo.2020.00016

Jian, Z., Bo, L., & Mingyue, W. (2018). Study on windbreak performance of tree canopy by numerical simulation method. *The Journal of Computational Multiphase Flows*, *10*(4), 259-265. Doi: https://doi.org/10.1177/1757482X18791901

Joye, Y. (2007). Architectural lessons from environmental psychology: The case of biophilic architecture. *Review of General Psychology*, *11*(4), 305-328. Doi: https://doi.org/10.1037/1089-2680.11.4.305

Kabisch, N., Qureshi, S., & Haase, D. (2015). Human–environment interactions in urban green spaces—A systematic review of contemporary issues and prospects for future research. *Environmental Impact Assessment Review*, *50*, 25-34. Doi: https://doi.org/10.1016/j.eiar.2014.08.007

Klingberg, J., Broberg, M., Strandberg, B., Thorsson, P., Pleijel, H. (2017). Influence of urban vegetation on air pollution and noise exposure—A case study in Gothenburg, Sweden. *Sci. Total Environ.*, 1728–1739. Doi: https://doi.org/10.1016/j.scitotenv.2017.05.051

Kondo, M. C., Fluehr, J. M., McKeon, T., & Branas, C. C. (2018). Urban green space and its impact on human health. *International Journal of Environmental Research and Public Health*, *15*(3), 445. Doi: https://doi.org/10.3390/ijerph15030445

Koyata, H., Iwachido, Y., Inagaki, K., Sato, Y., Tani, M., Ohno, K., ... & Sasaki, T. (2020). Factors determining on-site perception of ecosystem services and disservices from street trees in a densely urbanized area. *Urban Forestry & Urban Greening*, 126898. Doi: https://doi.org/10.1016/j.ufug.2020.126898

Lin, I. Y. (2004). Evaluating a services cape: the effect of cognition and emotion. *International Journal of Hospitality Management*, *23*(2), 163-178. Doi: https://doi.org/10.1016/j.ijhm.2003.01.001

Locosselli, G. M., & Buckeridge, M. S. (2023). The science of urban trees to promote well-being. *Trees*, 1-7. Doi: 10.1007/s00468-023-02389-2

Luo, L., & Jiang, B. (2022). From oppressiveness to stress: A development of Stress Reduction Theory in the context of contemporary high-density city. *Journal of Environmental Psychology*, *84*, 101883. Doi: https://doi.org/10.1016/j.jenvp.2022.101883

Lyytimäki, J., & Sipilä, M. (2009). Hopping on one leg–the challenge of ecosystem disservices for urban green management. *Urban Forestry & Urban Greening*, 8(4), 309–315. Doi: https://doi.org/10.1016/j.ufug.2009.09.003

Maas, J., Spreeuwenberg, P., Van Winsum-Westra, M., Verheij, R. A., Vries, S., & Groenewegen, P. P. (2009). Is green space in the living environment associated with people's feelings of social safety?. *Environment and Planning A*, 41(7), 1763-1777. Doi: https://doi.org/10.1068/a4196

MacGregor-Fors I, Ortega-Alvarez R (2011) Fading from the forest: bird community shifts related to urban park site-specific and landscape traits. *Urban For Urban Green*. Doi: https://doi.org/10:239–246

Nesbitt, L., Hotte, N., Barron, S., Cowan, J., & Sheppard, S. R. (2017). The social and economic value of cultural ecosystem services provided by urban forests in North America: A review and suggestions for future research. *Urban Forestry & Urban Greening*, *25*, 103-111. Doi: https://doi.org/10.1016/j.ufug.2017.05.005

Ng, S. K., Barron, D., & Swami, V. (2015). Factor structure and psychometric properties of the Body Appreciation Scale among adults in Hong Kong. *Body Image*, *13*, 1-8. Doi: https://doi.org/10.1016/j.bodyim.2014.10.009

Nohed, A. (2019). Värdet av träd. Doi: http://urn.kb.se/resolve?urn=urn:nbn:se:slu:epsilon-s-10755

Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening*, *4*(3-4), 115-123. Doi:

https://doi.org/10.1016/j.ufug.2006.01.007

Nowak, D.J., Dwyer, J.F., 2007. Understanding the benefits and costs of urban forest ecosystems. In: Kuser, J.E. (Ed.), *Urban and Community Forestry in the Northeast (2nd).* Springer Netherlands, Dordrecht, pp. 25–46. Doi: http://dx.doi. org/10.1007/978-1-4020-4289-8 2.

Nowak, D.J., Hirabayashi, S., Greenfield, E., (2014). Tree and forest effects on air quality and human health in the United States. *Environ. Pollut*. 193, 119–129. Doi: http://dx.doi.org/10.1016/j.envpol.2014.05.028

Oh, R. Y. R., Fielding, K. S., Nghiem, T. P. L., Chang, C. C., Shanahan, D. F., Gaston, K. J., ... & Fuller, R. A. (2021). Factors influencing nature interactions vary between cities and types of nature interactions. *People and Nature*, *3*(2), 405-417. Doi: 10.1002/pan3.10181

Onelius, C., & Sjölin, L. (2021). Trädens roll i den hållbara staden: En fallstudie av träd i centrala Gävles grönområden. Doi: urn:nbn:se:hig:diva-36534

Ordóñez, C., & Duinker, P. N. (2013). An analysis of urban forest management plans in Canada: Implications for urban forest management. *Landscape and Urban Planning*, *116*, 36-47. Doi: https://doi.org/10.1016/j.landurbplan.2013.04.007

Qamhieh, D. (2012). Intermodal Terminals Node-Place Issue and Travelers´ Flow: Case study: Gothenburg central station. Doi: urn:nbn:se:kth:diva-109834

Potchter, O., Cohen, P., Bitan, A., (2006). Climatic behavior of various urban parks during hot and humid summer in the mediterranean *City of Tel Aviv, Israel. Int. J. Climatol*. 26, 1695–1711. Doi: http://dx.doi.org/10.1002/joc.

Rahman, M.A., Armson, D., Ennos, A.R., (2015). A comparison of the growth and cooling effectiveness of five commonly planted urban tree species. *Urban Ecosyst*., 18 (2) pp. 371-389.

Rahman, M. A., Moser, A., Rötzer, T., & Pauleit, S. (2019). Comparing the transpirational and shading effects of two contrasting urban tree species. *Urban Ecosystems*, *22*, 683-697. Doi: https://doi.org/10.1007/s11252-019-00853-x

Rahman, M. A., Hartmann, C., Moser-Reischl, A., von Strachwitz, M. F., Paeth, H., Pretzsch, H., ... & Rötzer, T. (2020). Tree cooling effects and human thermal comfort under contrasting species and sites. *Agricultural and Forest Meteorology*, *287*, 107947. Doi: https://doi.org/10.1016/j.agrformet.2020.107947

Randrup, T. B., Konijnendijk, C., Dobbertin, M. K., & Prüller, R. (2005). The concept of urban forestry in Europe. In *Urban Forests and Trees: A Reference Book* (pp. 9-21). Berlin, Heidelberg: Springer Berlin Heidelberg.

Rathoure, A. K., & Modi, J. (2019). Zero Noise Pollution: Green Belt Development. *Zero Waste* (pp. 25-49). CRC Press.

Roy, S., Byrne, J., & Pickering, C. (2012). A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. *Urban Forestry & Urban Greening*, *11*(4), 351-363. Doi: https://doi.org/10.1016/j.ufug.2012.06.006

Rötzer, T. (2019). *Growth and Ecosystem Services of Urban Trees*. MDPI.

Sander, H. A., & Haight, R. G. (2012). Estimating the economic value of cultural ecosystem services in an urbanizing area using hedonic pricing. *Journal of Environmental Management*, *113*, 194-205. Doi: https://doi.org/10.1016/j.jenvman.2012.08.031

Sanesi, G., & Chiarello, F. (2006). Residents and urban green spaces: The case of Bari. *Urban Forestry & Urban Greening*, *4*(3-4), 125-134. Doi: https://doi.org/10.1016/j.ufug.2005.12.001

Sartorius, N. (2006). The meanings of health and its promotion. *Croatian Medical Journal*, *47*(4), 662. Doi: https://doi.org/47(4): 662–664

Shackleton, C. M., & Mograbi, P. J. (2020). Meeting a diversity of needs through a diversity of species: Urban residents' favourite and disliked tree species across eleven towns in South Africa and Zimbabwe. *Urban Forestry & Urban Greening*, *48*, 126507. Doi: https://doi.org/10.1016/j.ufug.2019.126507

Shashua-Bar, L. & Hoffman, M.E. (2000). Vegetation as a climatic component in the design of an urban street - an empirical model for predicting the cooling effect of urban green areas with trees. *Energy Build*., 31 (3), pp. 221-235. Doi: https://doi.org/10.1016/S0378-7788(99)00018-3

Shashua-Bar, L., Potchter, O., Bitan, A., Yaakov, Y., 2010. Microclimate modelling of street tree species effects within the varied urban morphology in the Mediterranean city of Tel Aviv, Israel. *Int. J. Climatol*. 30, 44–57. Doi: http://dx.doi. org/10.1002/joc

Sicard, P., Agathokleous, E., Araminiene, V., Carrari, E., Hoshika, Y., De Marco, A., & Paoletti, E. (2018). Should we see urban trees as effective solutions to reduce increasing ozone levels in cities? *Environmental Pollution*, *243*, 163–176. Doi: https://doi.org/10.1016/j.envpol.2018.08.049

Sjöman, H., & Slagstedt, J. (2015). Träd i urbana landskap (1:1. uppl.). Lund: Studentlitteratur.

Sjöman, H., Slagstedt, J., Wiström, B. & Ericsson, T. (2015). Naturen som förebild. Doi: http://urn.kb.se/resolve?urn=urn:nbn:se:slu:epsilon-s-500571

Smith, W. G. (2008). Does gender influence online survey participation? A record-linkage analysis of university faculty online survey response behavior. *Online Submission*. Doi: https://eric.ed.gov/?id=ED501717

Stantcheva, S. (2022). How to run surveys: A guide to creating your own identifying variation and revealing the invisible. *Annual Review of Economics*, *15*. Doi: https://doi.org/10.1146/annurev-economics-091622-010157

Szota, C., Coutts, A. M., Thom, J. K., Virahsawmy, H. K., Fletcher, T. D., & Livesley, S. J.

(2019). Street tree stormwater control measures can reduce runoff but may not benefit established trees. *Landscape and Urban Planning*, *182*, 144-155. Doi: https://doi.org/10.1016/j.landurbplan.2018.10.021

Taherdoost, H. (2019). What is the best response scale for survey and questionnaire design; review of different lengths of rating scale/attitude scale/Likert scale. *International Journal of Academic Research in Management (IJARM),* 8, (1),1-10. Doi: https://ssrn.com/abstract=3588604

Tekiela, S. (2020). *Trees of Minnesota field guide*. Adventure Publications.

Tiwary, A., Sinnett, D., Peachey, C., Chalabi, Z., Vardoulakis, S., Fletcher, T., ... & Hutchings, T. R. (2009). An integrated tool to assess the role of new planting in PM10 capture and the human health benefits: A case study in London. *Environmental Pollution*, *157*(10), 2645-2653. Doi: https://doi.org/10.1016/j.envpol.2009.05.005

Trost, J. (2012). Enkätboken (4:1. uppl.). Lund: Studentlitteratur.

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., & Kagawa, T. (2014). The influence of urban green environments on stress relief measures: A field experiment. *Journal of Environmental Psychology*, *38*, 1-9. Doi: https://doi.org/10.1016/j.jenvp.2013.12.005

Van den Berg, B., Walgaard, C., Drenthen, J., Fokke, C., Jacobs, B. C., & Van Doorn, P. A. (2014). Guillain–Barré syndrome: pathogenesis, diagnosis, treatment and prognosis. *Nature Reviews Neurology*, *10*(8), 469-482. Doi: https://doi.org/10.1038/nrneurol.2014.121

Van den Bosch, M., & Sang, Å. O. (2017). Urban natural environments as nature-based solutions for improved public health–A systematic review of reviews. *Environmental Research*, *158*, 373-384. Doi: https://doi.org/10.1016/j.envres.2017.05.040

Velarde, M. D., Fry, G., & Tveit, M. (2007). Health effects of viewing landscapes–Landscape types in environmental psychology. *Urban Forestry & Urban Greening*, *6*(4), 199-212. Doi: https://doi.org/10.1016/j.ufug.2007.07.001

Viippola, V., Whitlow, T. H., Zhao, W., Yli-Pelkonen, V., Mikola, J., Pouyat, R., & Setälä, H. (2018). The effects of trees on air pollutant levels in peri-urban near-road environments. *Urban Forestry & Urban Greening*, *30*, 62-71. Doi: https://doi.org/10.1016/j.ufug.2018.01.014

Wenzel, A., Grass, I., Belavadi, V. V., & Tscharntke, T. (2020). How urbanization is driving pollinator diversity and pollination–A systematic review. *Biological Conservation*, *241*, 108321. Doi: https://doi.org/10.1016/j.biocon.2019.108321

Willis, K. J., & Petrokofsky, G. (2017). The natural capital of city trees. *Science*, *356*(6336), 374-376. Doi: https://doi.org/10.1126/science.aam9724

Wolf, K. L., Lam, S. T., McKeen, J. K., Richardson, G. R., van den Bosch, M., & Bardekjian, A. C. (2020). Urban trees and human health: A scoping review. *International Journal of Environmental Research and Public Health*, *17*(12), 4371. Doi: https://doi.org/10.3390/ijerph17124371

Yang, J., Chang, Y., & Yan, P. (2015). Ranking the suitability of common urban tree species for controlling PM2. 5 pollution. *Atmospheric pollution research*, *6*(2), 267-277. Doi: https://doi.org/10.5094/APR.2015.031

Yang, Y., Jing, L., Li, Q., Liang, C., Dong, Q., Zhao, S., ... & Wang, W. (2023). Big-sized trees and higher species diversity improve water holding capacities of forests in northeast China. *Science of The Total Environment*, *880*, 163263. Doi: https://doi.org/10.1016/j.scitotenv.2023.163263

Yin, S., Shen, Z., Zhou, P., Zou, X., Che, S., & Wang, W. (2011). Quantifying air pollution attenuation within urban parks: An experimental approach in Shanghai, China. *Environmental Pollution*, *159*(8-9), 2155-2163. Doi: https://doi.org/10.1016/j.envpol.2011.03.009

Yli-Pelkonen, V., Setälä, H., Viippola, V. (2017). Urban forests near roads do not reduce gaseous air pollutant concentrations but have an impact on particles levels. *Landsc. Urban Plan.*, 158, 39–47. https://doi.org/10.1016/j.landurbplan.2016.09.014

Zastrow, M. (2019). China's tree-planting could falter in a warming world. *Nature*, *573*(7775), 474-475. Doi: https://doi-org.ezproxy.ub.gu.se/10.1038/d41586-019-02789-w

Zhang, Y., Hussain, A., Deng, J., & Letson, N. (2007). Public attitudes toward urban trees and supporting urban tree programs. *Environment and Behavior*, *39*(6), 797-814. Doi: https://doi.org/10.1177/0013916506292326

Zhao, N., Prieur, J. F., Liu, Y., Kneeshaw, D., Lapointe, E. M., Paquette, A., ... & Smargiassi, A. (2021). Tree characteristics and environmental noise in complex urban settings–A case study from Montreal, Canada. *Environmental Research*, *202*, 111887. Doi: https://doi.org/10.1016/j.envres.2021.111887

8. Appendix

Appendix A. – Survey

Perception of urban trees and their benefits

The purpose of this survey is to gather information about your perception of urban trees and their various benefits. With the intention of contributing to the understanding of what type of trees people prefer in the urban environment, and why.

Your information is anonymous, the following information is only to be compiled and presented in a degree project at the University of Gothenburg in the form of tables and diagrams.

The survey takes about 7 minutes to complete.

1. **Gender**

- ◯ Man
- ◯ Woman
- ◯ Other
- ◯ Prefer not to say

2. **Age**

- ◯ 18 - 25
- ◯ 26 - 35
- ◯ 36 - 45
- ◯ 46 - 55
- ◯ 56 - 65
- ◯ > 65

3. **Characteristics**

Which of these tree types do you consider most attractive in an urban environment?

Rank the trees on a scale from **1** - "Most attractive" to **8** - "Less attractive":

- A
- B
- C
- D
- E
- F
- G
- H

4. Which of the following characteristics contribute to the tree you ranked rank 1 in question 3, being the **MOST** attractive in an urban environment?

Tick the 3 options that fit best.

- ☐ Tall tree
- ☐ Short tree
- ☐ Large tree canopy
- ☐ Small tree canopy
- ☐ Leaves with simple shape
- ☐ Leaves with complex shape
- ☐ Hanging branches
- ☐ Colourful leaves
- ☐ Compact tree canopy
- ☐ Sparse tree canopy
- ☐ Short needles
- ☐ Long needles
- ☐ Other

5. Which of the following characteristics contribute to the tree you ranked rank 1 in question 3, being the **LESS** attractive in an urban environment?

Tick the 3 options that fit best.

- ☐ Tall tree
- ☐ Short tree
- ☐ Large tree canopy
- ☐ Small tree canopy
- ☐ Leaves with simple shape
- ☐ Leaves with complex shape
- ☐ Hanging branches
- ☐ Colourful leaves
- ☐ Compact tree canopy
- ☐ Sparse tree canopy
- ☐ Short needles
- ☐ Long needles
- ☐ Other

6. **Experience**

City trees and trees close to buildings make me experience the area as:

Rate on a scale from **1** - "Strongly disagree" to **7** - "Strongly agree".

	1	2	3	4	5	6	7
Beautiful	○	○	○	○	○	○	○
Safe	○	○	○	○	○	○	○
Happiness increasing	○	○	○	○	○	○	○
Pleasant	○	○	○	○	○	○	○
Stress reliving	○	○	○	○	○	○	○

7. **Benefits**

What do you think is most important about urban trees?

Tick the 3 options that fit the best.

- ☐ Provides shade
- ☐ Beautifies the environment
- ☐ Filters particles and cleans the air from impurities
- ☐ Reduces noise
- ☐ Provides shelter from the wind
- ☐ Makes me feel good
- ☐ Provides nectar and pollen to pollinators
- ☐ Habitat for animals
- ☐ Reduces the risk of flooding
- ☐ Absorbs carbon dioxide
- ☐ Other

8. Which tree, from picture A - H, do you think contributes the most to the benefits you chose in the question above?

Enter your answer

9. Why do you think the chosen tree has that impact?

Enter your answer

10. **Negative aspects**

Do you think there is anything negative about urban trees?

If YES, what n**egative aspects** do you think urban trees can have?

Enter your answer

Appendix B. - Complete list of the tree characteristics asked about in the survey.

Shortened characteristics	Characteristics
Tall tree	Tall tree
Short tree	Short tree
L. canopy	Large tree canopy
S. canopy	Small tree canopy
Simple leaves	Leaves with simple shape
Complex leaves	Leaves with complex shape
Hanging branches	Hanging branches
Colourful	Colourful leaves
Cmpt canopy	Compact tree canopy
Sparse canopy	Sparse tree canopy
Sh. needles	Short needles
Lo. needles	Long needles
Other	Other

Appendix C. - Complete list of the urban tree benefits asked about in the survey.

Shortened	Full sentence of benefits in the survey
Shade	Provides shade
Beautifies	Beautifies the environment
Filters air	Filters particles and cleans the air from impurities
Red. noise	Reduces noise
Wind shelter	Provides shelter from the wind
Pleasing	Makes me feel good
Nectar & pollen	Provides nectar and pollen to pollinators
Habitat	Habitat for animals
Red. Flooding	Reduces the risk of flooding
Absorbs CO2	Absorbs carbon dioxide
Other	Other