Tampere University of Applied Sciences

Comparing the Finnish urban forest recommendations with the health effects of forests

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ABSTRACT

Tampereen ammattikorkeakoulu
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NURMI, ANSSI:
Comparing the Finnish urban forest recommendations with the health effects of forests

Bachelor's thesis 44 pages, appendices 2 pages
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The purpose of this thesis was to compare Finnish urban forest management recommendations with articles connecting human health and forest. The goal was to look at the urban forest recommendations from the point of view of human well-being, as well as to find forest variables that might increase health benefits.

The search for the articles correlating forest with human health was a Boolean search performed on Scopus, Academic Search Ultimate, and Web of Science in March 2021. The search was narrowed down into 34 articles, from which the variables and health effects were collected into a database. Collecting material about Finnish urban forest management began in September 2021. Results from the articles were compared with the urban forest management recommendations.

The most common health benefits from forests were improved mood, restoration, relaxation, and reinvigoration. The outcome of the comparison show that forest have generally a high number of positive health effects and social benefits. The most liked forests were relatively sparce, light pine forests with large trunks, and the most disliked forest were closed, dark forests with thick undergrowth. Finnish urban forest recommendations were mostly in accordance with the results from the article database. Forest soundscape, a popular quality in the article results, was not mentioned in the recommendations.

The forest descriptions used in the articles were often scarce and vague. Forming accurate assumptions of health benefits correlation to forest variables was difficult due to the large number of sensory stimuli to subjects from real-life forest exposure. The results of the articles cannot be extrapolated to the rest of the world, as the articles were either from Europe or Asia.

Based on the information, Finnish urban forest can have significant positive health effects. More studies are required so that we can more deeply understand the connection between the effects of forest variables and human well-being.

Key words: urban forest management, human well-being, human health, forest variable, forest type

TIIVISTELMÄ

Tampereen ammattikorkeakoulu
Metsätalouden tutkinto-ohjelma

NURMI, ANSSI:
Suomen taajamametsien hoitosuositusten vertailu metsien terveysvaikutuksiin

Opinnäytetyö 44 sivua, joista liitteitä 2 sivua
Helmikuu 2022

Tässä opinnäytetyössä tutkitaan taajamametsien hoitosuosituksia ja verrataan niitä metsien terveyshyödyistä tehtyihin artikkeleihin. Työssä tarkastellaan suomalaisten taajamametsien suosituksia ihmisten hyvinvoinnin näkökulmasta sekä tutkitaan, onko joillain metsän muuttujilla havaittu vaikutuksia terveyteen.

Artikkelihaku ihmisten terveyden ja metsien korrelaatiosta tapahtui Boolen haulla kolmella eri hakukoneella maaliskuussa 2021. Haun ja analyysin perusteella valikoitui 34 artikkelia, joista kerättiin metsän muuttujat ja terveysvaikutukset tietokantaan. Materiaalihaku Suomen taajamametsien suosituksista alkoi syyskuussa 2021. Artikkeleista kerättyjä tietoja vertailtiin taajamametsien suositusten kanssa.

Yleisimmät metsien terveyshyödyt ovat parantunut mieliala, palautuminen, rentoutuminen ja virkistyminen. Vertailu osoitti, että metsillä on yleisesti suuri määrä positiivisia terveysvaikutuksia ja sosiaalisia hyötyjä. Pidetyimmät metsät olivat suhteellisen harvoja, valoisia mäntymetsiä, joissa kasvoi järeitä puita, kun taas vähiten pidetyt olivat sulkeutuneita, pimeitä metsiä, joissa oli tiheä pensaskerros. Suomen taajamametsien suositukset ovat pitkälti yhtenevät artikkeleissa ilmenneiden tulosten kanssa. Metsien äänimaailma mainittiin positiivisena metsän piirteenä artikkeleissa, mutta siitä ei ollut suosituksissa mainintaa.

Metsien kuvailu artikkeleissa oli yleisesti niukkaa ja epämääräistä. Korrelaatio terveyshyötyjen ja metsän muuttujien välillä on hankalaa, koska metsäkäynneillä tutkittaviin henkilöihin kohdistuu suuri määrä aistiärsykkeitä. Artikkeleiden tuloksia ei voida yleistää maailmanlaajuisiksi, koska kaikki artikkelit olivat joko Euroopasta tai Aasiasta.

Näiden tietojen perusteella Suomen taajamametsillä on merkittäviä terveyshyötyjä. Metsän muuttujien ja ihmisterveyden välisen yhteyden ymmärtämiseksi tarvitaan lisää tutkimustietoa.

Asiasanat: taajamametsien hoito, terveysvaikutus, metsän muuttuja, metsätyyppi

CONTENTS

1 INTRODUCTION

In an ever-urbanizing world, urban forests are the closest link to nature for most people. People visit forests for several reasons, for example to relax and blow off steam, refresh their minds, do sports or to pick berries. While the ongoing urbanization has reduced the number of urban forests and access to forests can be inconvenient, law makers and politicians have started to acknowledge forests' social, ecological, and environmental benefits. This can be seen on the shift of forest policy agendas' focus on conservation, recreation and forests' health promoting characteristics (Anttila 2020, 25-29; Ordóñez & Duinker 2013; Tyrväinen 2020).

Konijnendijk, C. C. et al. (2005) groups the benefits of urban forests into five distinctive categories. Those benefits are social, aesthetic and architectural, climatic and physical, ecological, and economic. Although importance of each of the benefit vary largely in different parts Europe due to environmental and socio-cultural atmosphere, they are recognized in urban forest development processes that shape the urban forests around residential areas.

The knowledge about health benefits of urban forests is increasing year by year as studies focus their attention to not only curing the diseases and ill health, but by recognizing the impact of hazardous lifestyle. This lifestyle can be related to a sedentary, stressful, and increasingly indoor way of life. Antidote for some of the effects can be found in the nature, as it offers an incentive for physical exercise and restorative relaxation (Nilsson et al. 2011).

According to studies about people's preferred location where they would like to retreat from a stressful situation, gather thoughts and be alone, we tend to choose often natural environments (Aura et al. 1997). Even in a city environment, favourite place is often found in forest (Simkin et al. 2021). According to studies by Ulrich (1984) and Kaplan & Kaplan (1989), these environments seem to possess strong restorative effect on people both physically and mentally.

In addition to their restorative effects, natural environments are possibly in a vital position in battling growing numbers of cardiovascular disease, type II diabetes as well as respiratory problems (Steg et al. 2013). While natural environments do not force people to do more physical activity, they have an inherent quality that promotes physical activity. This is because these green spaces are perceived more attractive than urban areas, and physical activity, such as walking or cycling is often required to experience them (Nilsson et al. 2011).

A study by Tyrväinen (2001) hinted a connection between a monetary value of a Finnish city district and its proximity to an urban forest. Higher value was related to nature and social functions rather than forest's economic value. Tyrväinen suggested that inhabitants are willing to pay to use green recreation area, and good location and active management increased neighborhoods perceived value. The results also showed that monetary value of recreational areas is higher than their maintenance cost.

In this thesis I will look at urban forest management recommendations in Finland and compare them with forest attributes that are linked to human health benefits. To limit the extent of this thesis, recommendations of only one specific country is studied. Finland is chosen as the target country due to material availability and language limitations. After collecting information regarding urban forest management recommendations in Finland, an article search connecting forest experiences to human health is performed. From these articles the variables are collected, as well as the qualities that were said to make up positive or negative experience. Once the variables and qualities are recorded, they are compared to Finnish urban forest recommendations.

The aim of this thesis is to shed light on how urban forest planning and management can affect human health and prevent unhealthy conditions. The results are likely to bring uniformity between urban forest planning recommendations and health effects as well as discern disparities between the two. The concrete purpose is to understand well-being benefits behind different urban forest objectives, and to find out how forest variables influence humans.

2 URBAN FOREST MANAGEMENT IN FINLAND

2.1 Municipality forests in Finland

Forests cover about 75 % of the land area in Finland, making it the most forest covered country in Europe in relation to its size. Total area covered by forests is 23,8 million hectares (Ministry of Agriculture and Forestry of Finland). Based on the statistics from the website of Kuntaliitto (municipality alliance), Finnish municipalities owned approximately 430 000 hectares of forests in 2013. Nearly every municipality (98 %) owns forests, and of all the 309 municipalities 125 own over 1000 hectares and 32 have over 3000 hectares. In 2014 the average amount of municipality forest was 1400 hectares and median were 812 hectares (Anttila 2020, 12).

Most of the Finnish population lives in cities and towns. Despite the numerous green areas in Finnish cities, growth centres require more residential areas, therefore placing more pressure on the surrounding urban forest. Although the focus of green area planning has been on ecological values, the focus is shifting more towards inhabitants' well-being and social surroundings (Tyrväinen 2007).

The forests of municipalities are divided into different classes based on their purpose. Of all the municipality forests, 51 % are classified as commercial forests, 42 % are recreational forests and approximately 7,5 % are conservation forests (Kuntaliitto.fi). According to a survey by Anttila (2020, 12), 80 % from the 79 municipalities that took part in a survey were considering converting more commercial forests into recreational forests and half of the municipalities thought of turning some of the forests into conservation forests.

There are manuals that offer guidelines for Finnish urban forest management and procedures, for example "Taajamametsien hoito" by Komulainen (1995) and "Taajamametsät – suunnittelu ja hoito" by Hamberg et al. (2012). While content of both books is similar, the latter being more recent, updated book, most of the urban forest recommendations in this thesis will be referring to the information given there. It should be noted that the book by Hamberg et al. is currently being updated and it will not be published before the end of 2022. Other frequently referred materials are “Metsä maisemassa – Suunnittelu ja hoito” by Komulainen (2012) and “Monitavoitteinen metsäsuunnittelu kuntametsissä - kirjallisuuskatsaus” by Anttila (2020). The book by Komulainen offers suggestions on how to manage and plan a forest landscape in Finland, and literary survey by Anttila clarifies the development of Finnish urban forests in the last ten years.

2.2 Urban forest planning in Finland

2.2.1 Governing factors in urban forest development

In urban forest planning multi-purpose use and users’ different goals are emphasized (Hamberg et al. 2012, 52-53). According to a review by Anttila (2020, 11), three main factors for sustainable development of urban forests are economic, social, and ecologic sustainability. Anttila states that economic sustainability produces well-being, as well as stability for the future and protects forest’s productivity and vitality. Social sustainability secures social well-being and maintains possibilities for future generations, while ecologic sustainability aims to preserve biodiversity and water conservation to name a few. Balancing these three factors is a high priority for municipalities and they are required by law to preserve their stability (Constitution of Finland 20 §, Local Government Act 1 § and Conservation Act 6 §).

Functions and purposes of urban forests depend on their location, characteristics, and possibilities. Location of forest affects the purpose of use, visual aspects, shapes, and scale of procedures. For instance, forest’s transparency increases visual appreciation at waterfronts, as opposed to protection forests near industrial areas or highways where dense forests are used as visual cover and protection from exhaust gases, dust and other fine particles (Hamberg et al. 2012, 116-117). Common objectives for Finnish urban forests are nature conservation, recreational use, commercial income, carbon capture and water conservation (Anttila 2020, 6). In 2007 new recommendation for urban forest management classification was set for these objectives to integrate municipalities’ forest management procedures and facilitate urban forest planning process. The management classes are near-by forest, recreational forest, protection forest, economic forest, and value forest. Municipalities assess the objectives and goals for urban forests based on land-use planning aims and demand (Hamberg et al. 2012, 56).

2.2.2 Urban forest planning levels

Urban forest planning is divided into three sub-classes: strategic, tactic and operative planning. Strategic planning answers the question why municipality owns forest, as well as determines the objectives and future goals for the forest. Tactical planning aims to create a procedure plan for each forest stand for the next 10 years. Operative planning defines forestry procedures in practise and gives details to carry out daily operations (Hamberg et al. 2012, 55).

Depending on the objectives set for the forest, urban forest plan is usually produced by either municipality’s own planner or planning is outsourced to an external party. Anttila (2020, 13) found out that outsourcing forest planning is more common for forests with commercial income as the main purpose, and in recreational forest nearly half of the plans are put together by municipality’s own forestry expert.

Just as in private forest ownership, building a mutual understanding between the forest planner and the owner is vital when creating a successful long term urban forest plan. Defining forest owner’s values and goals, as well as presenting several forestry procedure possibilities and outcomes for different forest objectives are crucial to having satisfactory results. Compromises between different forest goals are inevitable because a growing number of urban forests have combined uses, and optimum results for all are not possible to reach simultaneously. Despite this, with well thought-out planning it is possible to achieve satisfying results (Hamberg et al. 2012, 52).

2.2.3 Operative planning process

Once the values and objectives for municipality's urban forest are set, planning process begins by gathering information about geography, forest resources, infrastructure, nature and landscape values, recreational use, and opinions related to the forest stand. Geographic, forest resource, and infrastructure information is gathered from terrain maps, planning software and by visits to the area. Hill-tops, slope forests, forest edges and waterfront forests are examined and mapped. These areas are assessed and graded based on their visual sensitivity and possibilities for procedures are determined. During forest visits visual coherence is studied and important visual elements are defined. Visual diversity is assessed by examining its details, such as visually valuable trees or tree groups (Hamberg et al. 2012, 67). Assessing visual aspects based on numeric tree stand values should be avoided, as the base level visual variables, such as lines, shapes, colours, and textures are difficult to illustrate (Silvennoinen 2017, 55).

It is essential to engage and include municipality personnel, professionals, recreational users, and inhabitants to collect their opinions and views about management options and survey social values. Inhabitants and recreational users can be involved in different parts of the planning process with questionnaires, public events, meetings, interviews or walk-along are organized to gather information about preferred locations and landscapes, as well as safe and hazardous areas. In addition to this, inhabitants can give information about local history and traditional land use. Anttila (2020, 6; 22) found that informing and engaging inhabitants especially in the early stages of the planning process is essential. Although feedback might be contradictory and some inhabitants and recreational users uninformed about forest ecology or silviculture, thus not understanding long-term benefits of procedures, inclusion increases collaboration and transparency, transmits information, and generates general acceptance towards management procedures (Hamberg et al. 2012, 65).

An example of a successful case of involving locals in a green space management and development is the planning process of Puijo hill in the town of Kuopio, Finland. The plan for the 500-ha green space was developed in 2008-2010 by involving locals in different parts of the planning process (figure 1). The opinions and propositions of the local inhabitants, organisations and associations were taken into considerations when defining the objectives for the area. Once the feedback was gathered and evaluated, objectives and criteria were set and informed to the public along with a timeline of the planning process. Based on the objectives and criteria of each area, the planner produced alternative plan options and assessed their economic, ecological, visual, and recreational effects. A seminar was organised for locals to review the alternative plans, and the opinions were considered when making the final decision (Hamberg et al. 2012, 68-69).

The aim of the operative planning process is to support the aims and goals of the owner by presenting one or several forest management proposals. Based on the information mentioned before, procedure options are prepared and presented to the owner. The proposed management plans should be validated by simulating numeric values or illustrating the effects with other tools. Numeric values are used to illustrate net profit, timber growth, number of users, land area ratios, and procedure land areas. Certain goals and values, such as landscapes after procedure, unity of living environments and cultural values, should be visualized with maps and simulation models (Hamberg et al. 2012, 58).

Based on the assessment of the procedure options and possible inclusion of interest groups plan is either approved or modified to suit the needs of the municipality (figure 1). Before operative planning shifts into tactical planning, some factors should be taken into consideration. Important factors to be evaluated are procedures near buildings, parking lots, electric grid, roads and walking trails, and other parts of infrastructure. In addition to this, inhabitants and recreational users must be informed about incoming procedures to avoid dangerous situations (Hamberg et al. 2012, 57, 62).

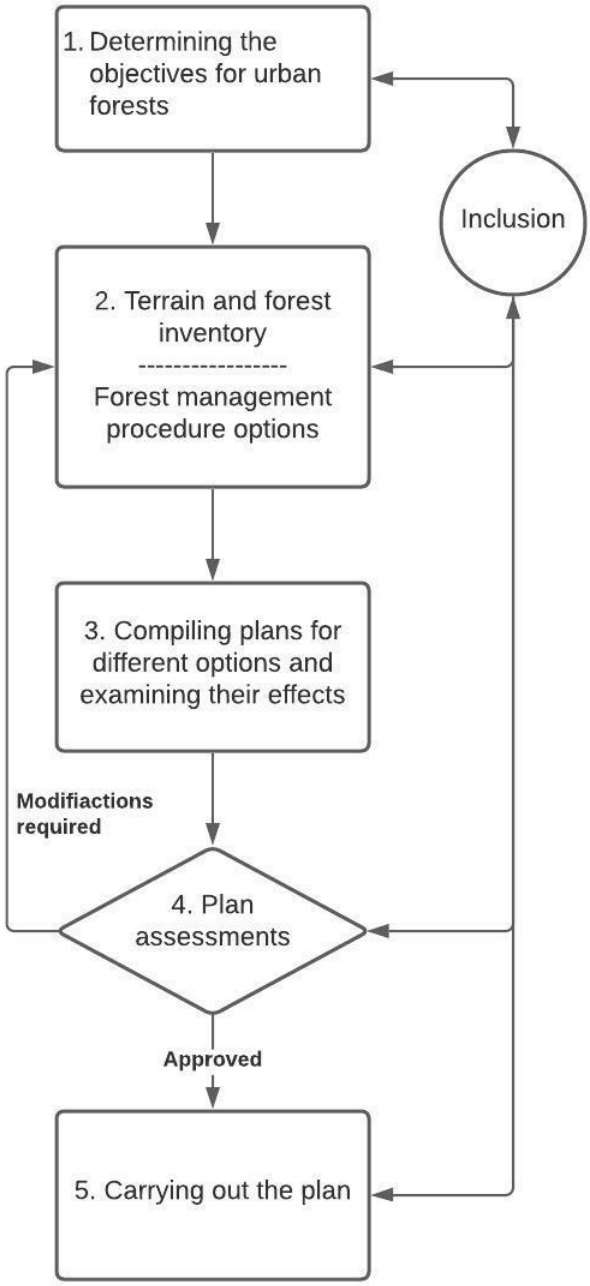

FIGURE 1. Translated from Hamberg, L. et al. 2013, 59. Urban forest planning process chart.

2.3 Landscape planning and visual preferences

Landscapes influence people's well-being and cultural identity. When people are asked to describe their favorite landscape, they often have a particular place in mind and feel strongly if it is threatened, thus having a strong affection towards a landscape (Steg et al. 2013). In addition to this, forest views are considered to expedite recovery after surgery, as was shown on Ulrich's study from 1984. In this study gall bladder surgery patients had either a view to a forest or a brick wall. Patients who saw forest spent on average 7.96 days in the hospital compared to 8.70 days for patients with a view to a brick wall. This reinforces the idea that a forest view can augment cell-repairing mechanisms.

Visual landscape qualities are viewed either from objective or subjective standpoint. From objective standpoint visual quality is inherent to the landscape in question, while from a subjective standpoint the landscape qualities form in the mind of the observer, i.e., 'beauty is in the eye of the beholder'. Until recently environmental management approach has been largely focused on the objective approach, in which experts use their formal knowledge to determine the aesthetics of the landscape, as opposed to the subjective approach, which is the focus of studies on visual landscape qualities (Steg et al. 2013)

Visual preference is considered a subjective experience and natural environments attract people differently. In a study about the significance of nature to city dwellers and its effect on psychological well-being (Tyrväinen et al. 2007), about half of the study participants considered natural environments as very appealing, while 5 % found city as the most appealing. It should also be noted that landscape effects of forestry procedures, such as tree felling, are perceived differently between different user groups. For example, forest owners or forestry professionals are more likely to approve logging residue in landscape than a recreational forest user (Silvennoinen 2017, 43).

In a study by Schroeder & Anderson (1984) college students used photographs to evaluate urban recreation sites for their perceived safety and scenic quality. Perceived safety was increased by visibility and developed park features, while scenic quality was increased by a high degree of vegetation and naturalness. Decreasing factors for park's scenic quality were for example fences, parking lots, management negligence, dirtiness, and monotonic areas.

According to Komulainen (2012), characteristics of a landscape are based around geology, hydrology, and climate combined with land use history. People see environment as different spaces, shapes, figures, textures, difference in sizes, and single details. Some of those qualities are more striking than others, but the full view is a mixture of all elements. Komulainen describes the most important forest landscape factors as shape, scale, landscape lines, diversity, coherence, and the spirit of the place also known as genius logi. These factors are used to describe the forest landscape and help to retain important visual characteristics when planning a forest procedure.

Shapes form one of the strongest aspects of the visual landscape. They are formed from two-dimensional lines and three-dimensional shapes. People recognize regular, polygon-style geometric shapes as something artificial and man-made. Examples of these spaces are quadrangle fields, felling sites and artificial lakes. In contrast to this, natural shapes in the landscape tend to be irregular and organic. Therefore, artificial geometric shapes might collide with the sporadic and indistinguishable shapes of the natural landscape, resulting in an off-putting and disturbed view (Komulainen 2012).

To reduce the impact of colliding shapes, urban forest management procedures are carefully planned especially in visually sensitive areas such as hill-top forest to maintain landscape silhouettes, as well as in forests near populous and often visited areas, such as recreational forests and forests near common traffic routes. This is because visual sensitivity is related to terrain shape and the number of visitors. In addition to this, landscape plan is used to reduce landscape incoherence by recognizing common viewing directions, ‘natural looking’ forest edges, important open areas, and hill-top silhouettes (Hamberg et al. 2012, 30).

2.3.1 Visual preferences in short distance landscape

According to Komulainen (2012, 222) a view from 2-100 m is considered a short distance landscape. Silvennoinen (2017, 42) studied visual preferences of forests and the effects of forest treatments. He found out that the visual appreciation increases with tree volume and tallness, while a higher number of stems on the other hand decreases the appreciation. Birch and pine were regarded more popular as dominant tree species than spruce. Forest with a notable conifer understory was appreciated more than one layered forest, although it should be noted that visual penetration through stand should not be too limited (Edwards et al. 2012, 5). In urban forests visual appreciation decreases fast if they are kept unmaintained, and especially deciduous trees, such as *Sorbus aucuparia*, should be thinned from a thick understory regularly (Silvennoinen 2017, 42; Hamberg et al. 2012, 92).

Silvennoinen (2017, 46) and Edwards et al. (2012, 5) stated that clear-cut forest is the most unliked view for both Finnish people and other Europeans alike, although an open view is perceived considerably more likeable when it is covered in snow. According to Silvennoinen (2017, 44-45) the most significant growth in visual appreciation was achieved by thinning a closed young tree stand. Generally, tourists perceived closed forest more positively than Finns. Tourists also preferred an old economic forest over a forest in a natural state with larger amounts of decaying wood. In the study by Edwards et al. (2012, 5) the amount of dead wood was perceived more negatively in the Nordic region than in other parts of Europe. One possible explanation was that Central European visitors tend to stick to the forest paths, whereas Nordic people are customed to collect berries and mushrooms in the forest stand itself, where the presence of felling residue and decaying wood considerably hinders the activities.

Edwards et al. (2012, 5) found that variation between tree stands in recreational forests plays an important role in the Nordic region as well as in Central Europe. Tree stand variation means different tree species compositions, stand ages and management regimes along a 5 km path through a forest. The number of tree species is generally perceived a positive quality, although it is likely to be linked with other factors, such as visual penetration and number of tree layers (Edwards et al. 2012, 5; Silvennoinen 2017, 44-45). Komulainen (2012) mentions imagining forest as various, divergent spaces. These spaces can be open, half-open or closed, and have different elements in them. The variety of these spaces intrigue the user and create more interesting experience than a homogenous forest, if the forest's coherence is sustained.

2.4 Objectives for urban forests

Objectives for urban forests can variate from mitigating heat stress from cities to capturing carbon from the atmosphere (Pearlmutter et al. 2017). As mentioned in chapter 2.2.1, Finnish urban forest management policies emphasize multi-purpose use and different objectives depending on the location, natural and social characteristics, as well as possibilities. According to Anttila (2020, 6), the objectives for urban forests are nature conservation, recreational use, commercial income, carbon capture and water conservation. Planning and management of urban forests, however, depend on the management classes, which are usually determined by land use planning. These management classes are near-by forest, recreational forest, protection forest, economic forest, and value forest (Hamberg et al. 2012, 56).

2.4.1 Biodiversity in urban forests

Biodiversity can be dissected into three separate levels: genetical variation within a species, number of species, and variety of environments. The latter is the most used in urban forests management when assessing biodiversity. Population centers are formed usually in nutritious lands near bodies of water, which are generally rich in biodiversity. Increase in human population is usually harmful to natural environments as human activity causes wear and disturbances for urban flora and fauna (Hamberg et al. 2012, 34).

Biodiversity in urban forests is affected by three main factors, which are naturalness and origin of woodland, size, and intensity of forest interventions through management and use (Konijnendijk et al. 2005). According to a study by Peterken (1974), species richness in primary forests can be distinguished from secondary forests even after centuries due to certain species' lack of colonizing capabilities. A primary forest describes a forest which is undisturbed and without a significant human impact and secondary forest is a re-grown forest after forestry procedure, such as clear-cutting. Size affects biodiversity by having generally more different types of habitats, as well as having wildlife that require larger living space (Konijnendijk et al. 2005). Forest use intensity affects wildlife, as is found on a study by van der Zande & Vos (1984). They discovered that increasing recreational activities might negatively impact species that are susceptible to disturbances, such as breeding birds.

As more housing is built, urban forests are subject to forest fragmentation and marginal effect. The latter means that sunlight, air, and pollution enter the forest through the edge of the forest, therefore altering growing conditions. This difference in light, wind and pollution alters forest's microclimate, water economy and nutrient content, having an impact on vegetation that require a closed forest and reducing the number of growing environments. Marginal effect can affect as deep as 100 meters withing the forest, depending on the vegetation density near the forest's edge. In narrow, oblong shaped forests the marginal effect can have an effect practically everywhere. Consequently, forests that are round are more efficient at resisting the marginal effect. To reduce the marginal effect even further, dense, multi-layered stand with Norway spruce as the dominant species are preferred around the edge of the forest (Hamberg et al. 2012, 35).

Despite its downsides, marginal effect is important for several insect and bird species that require open, sunny spaces, and tree species that go along with them. The tree species that provide for these animals are for example *Salix caprea*, *Sorbus aucuparia*, and *Prunus padus*. A combination of different environments is important to maintain a diverse and healthy population of flora and fauna. Therefore, urban forest sizes are recommended to be over three hectares and preferably roundish in shape. Special attention should be kept maintaining green corridors between forests to enable for species to move between areas (Hamberg et al. 2012, 35-36).

Biodiversity increases with a diverse tree stand structure. This means having several tree species, trees of different ages, and an adequate amount of dead wood. A diverse tree stand structure enables species with different environmental requirements to thrive. For example, mycorrhizal fungi live in a symbiose with its companion species, herbivores that eat the leaves or needles of a specific tree species, as well as insects or fungi that require decaying wood of a specific tree species to survive. It should also be noted that the single most important reason for endangered forest species in Finland is the lack of robust decaying wood in economic forests (Hamberg et al. 2012, 36-37).

2.4.2 Recreation forest

As mentioned in the introduction, studies show that natural environment influences the physical activity rate. As shown in a study by Sjöström et al. (2006), people tend to do less physical activity and have more sedentary lifestyle than before. Whilst large scale intervention against obesity and lack of exercise is difficult to orchestrate, introducing easier access, possibilities and aesthetic attributes is shown to have significant association with physical outdoor activities (Humpel et al. 2002).

According to Anttila (2020, 20), Finnish city dwellers use forests mostly for walking and jogging, but also for cycling, skiing, picking berries or mushrooms as well as walking their dog. It was found that from different nature values especially outdoor activities and sports have the highest relative importance to their living area. Forest qualities that attract Finns are beauty, comfort, and peacefulness. Especially Finns prefer spacious forests with thick, big trees according to a study by Tyrväinen et al. (2007). Other qualities that were appreciated were open forests by shores and natural looking forests. As mentioned by Hamberg et al. (2012, 84), recreational users prefer variety in their surroundings. This means varying between different tree species, forest stand types, as well as different size trees. Regardless, variety should not be incoherent but structured and reasonable. Views to beautiful scenery, landmarks or other details can be opened to maintain user's the interest.

Recovery from work and stress in shown to have a connection to natural environments (Kaplan & Kaplan 1989). According to Tyrväinen et al. (2007), experience of recovery was highest in sports areas, natural areas, and waterfronts. It should also be noted that 80 % of the sports areas in the study were sawdust running tracks also located inside forests.

According to the report by Anttila (2020, 14) recreation forests in Finland are planned mostly by municipalities themselves and forest management associations. Forest operations aim to create variety of different environments within urban forests. Alternating factors can be density, mixture of tree species, vegetation layers etc. Natural possibilities should be used as much as possible; Forest thinning can open views to visually pleasing objects, such as bodies of water, interesting trees, and geographical shapes. Thinning also increases tree trunk thickness, which is a desired forest quality according to a study by Silvennoinen (2017, 42). He found also that the scenic value of a dense forest can be improved by thinning. Felling waste is regarded as negative and should be removed from the vicinity of popular forest tracks, although this procedure impoverishes the soil. Naturally dense, shadowy depressions should be left intact, reinforcing the feeling of naturalness and variety, as well as biodiversity values. Alternating densities and layers can create spaces with interesting light conditions. Scarce forests are easier to traverse and are considered safer than dense forests. Other important forest qualities to maintain are naturalness and feeling of a forest even during forestry procedures by leaving some tree coverage or retention trees (Hamberg et al. 2012, 94-95).

2.4.3 Protection forest

Protection forest is a forest whose main purpose is to reduce noise, provide visual cover, protection from wind and filter exhaust gases, dust, and other fine particles. Its maintenance aims to keep the level of protection high as well as keeping the forest healthy. Optimal structure of a protection forest depends on what it is supposed to protect from. For example, deciduous trees have different noise-cancelling and visual cover qualities than conifers (Hamberg et al. 2012, 116).

Visual protection forests are used to cover unwanted view, for example to an industrial area or between housing. Preferred trees for these forests are conifers, which do not shed leaves for winter and provide visual cover all year round. They are maintained with regular light selection felling and single tree felling operations to keep trees in good condition and visually pleasing. As little as one tree can break geometric shapes and provide partial visual cover (Hamberg et al. 2012, 117-118).

Wind protection forests are common near open spaces such on shores and fields, to reduce the effect of wind. The purpose is to create a buffer that pushes wind currents over the trees and stop wind passages from forming. Even single trees can create a wind buffer that disturbs the air flow. Trees with all-year round thick crown that reaches all the down to ground offer the most effective wind buffer. From Finnish tree species, spruce has previously mentioned qualities, but it can be relatively easily blown over in high winds due to its roots being fanned out mostly on the top levels of soil. Because of this, it is recommended to grow wind protection forests as multi-layered, mixed forests accompanied by a thick shrub layer, thus increasing wind durability and reducing the risk of trees being toppled. These forests should be harvested regularly, trees in poor health are felled and new tree saplings planted (Hamberg et al. 2012, 118).

Noise protection forests are used near highways, railroad tracks, and other areas that create noise pollution. Noise reducing effect is based on the reflection of sound waves from leaves, branches, and trunks. To achieve best noise buffering result, highways need for example about 100 m wide forest buffer to reflect the noises. Deciduous trees offer significantly better noise reducing qualities during summer and conifers during winter. Noise protection forests are usually mixed forests that are grown thick to maximize the noise barrier. Noise reducing effect declines as trees grow older and felling operations aim to keep trees young by carrying out light selection felling and single tree felling (Hamberg et al. 2012, 116-117).

Dust and air pollutant protection forests are located near highways and industrial areas, where they aim to trap particles within the forest and reduce wind carrying them over to inhabited areas. Wind gets filtered and different fine particles are caught by leaves, needles, branches, and trunks. Air pollutant protection forest should contain sparce, soft-leaved trees and shrubs on the source of pollution side to let wind enter the forest, rather than pushing wind over the forest. Trees such as *Alnus incana*, *Salix caprea*, and *Betula pubescens* endure pollutants better than conifers and regenerate better in sparce, open areas. Further inside the forest it is recommended to grow a tall, conifer dominated mixed forest to create air vortexes, thus increasing pollutant filtering. Forest maintenances aim to keep forest multi-layered, giving space also to shrubs. Because air pollutants and fine particles accumulate on trees, they reduce photosynthesis and shorten the lifespan, trees on the side of the pollutant source are regenerated younger than trees further inside the forest to maintain a high tree vitality (Hamberg et al. 2012, 117).

3 ARTICLE SEARCH ABOUT FOREST AND HUMAN HEALTH

3.1 Search method

Keyword and search term assessment was performed using the protocol of *Guidelines for Systematic Review and Evidence Synthesis in Environmental Management* (Collaboration for Environmental Evidence, 2013). Initial term scoping for the article search was executed using Boolean search on Scopus' search engine. Different search terms were analysed based on the title relevance and the number of search hits. An article by Pagès et al. (2020): *"How Should Forests Be Characterized in Regard to Human Health? Evidence from Existing Literature"* was read and the search terms that were used for the study trialled. After test searches a similar search configuration had proved successful and similar methodology was assumed.

The search was about the correlation of forest variables and human health. Keywords were assessed and identified, and search terms were divided into two separate search blocks: forest type and health effect. Search terms were then assessed with the Scopus' search engine for relevance and number of hits.

Search parameter for the Boolean search was ("forest type" OR "forest classification" OR "forest mapping" OR "forest resource" OR "forest inventory") AND ("human health" OR wellbeing OR "well-being" OR happiness OR comfort).

The search was performed in Scopus' search engine, Academic Search Ultimate and Web of Science in March of 2021, thus only articles released by then were included.

The search mounted to following number of hits:
Scopus: 238
Academic Search Ultimate: 112
Web of Science: 70

Resulting hits from combined searches amounted to 418 articles. An additional grey literature search was performed to find information outside traditional publishing and distribution channels. This material could be for example government documents and reports, policy statements, newsletters etc. Grey literature search was performed on Google's search engine, but no additional articles were added to the list. After this, articles were added to Mendeley application for a relevance assessment.

3.2 Relevance assessment

Duplicate articles were excluded from the list. After this, the results were screened by their titles, abstracts and keywords and unrelated articles were excluded from the article list. Only articles which studied the influence of forest environment to human health were eligible. Inclusion criteria were:

- Subject relevance
- Relevant study design
- Articles written in English
- Peer reviewed articles
- Relevant study outcome

After relevance assessment of the search, the list was narrowed down into 34 documents (appendix 1).

The timescale of the articles in the resulting list was spanning 15 years, from 2006 (Morita et al. 2006) to 2021 (Mostajeran et al. 2021; Zhu et al. 2021).

3.3 Collecting the variable database

After the relevance assessment, articles were read and variables occurring in each article were gathered into a database under the term they best matched with. Variable terms were divided into forest and visit variables; forest variables include information about the forest and visit variables consist of data information about a certain visit to the forest, such as season, weather on the day of visit and exposure length. Together with the variables, health effects from the forest environment were written down as well as the reported positive and negative forest qualities.

Categorizing forest variables proved to be difficult from time to time due to the use of paraphrasing to describe forest qualities and certain variable terms being synonymous or overlapping with others. These terms were thus allocated under one variable term to keep the database coherent. Similar variable terms were for example tree structure with canopy structure and growing season and growing degree days. It could also be argued that some variables are sub-variables of others, such as climate depiction including a framework for growing degree days or species composition gives a hint of forest type in question.

These sub-variables could be used to derive other variables that were not explicitly detailed in the article. For example, by combining basal area and height information a rough estimation of tree volume could be calculated. Similarly, a depiction of a primary forest could be hypothesized to have a certain level of naturalness, or a certain species composition can be used to rule out some forest types. To avoid confusion, only the variable terms mentioned in the article were identified and recorded into the database.

To avoid sub-variable terms having only one or two hits in the database, wide umbrella terms were used. For example, biomass variable contains both dead and living biomass. This reduces the number of sub-variables thus giving a more coherent idea of the level of characterization used in each article.

3.4 Article descriptions

From the total of 34 articles included in the list, half of them were published in Asia. There is a significant number of studies published in Asian countries about nature therapy, or “Shirin-yoku” as it is known in Japan. “Shinrin-yoku”, which can be translated to “taking in the forest atmosphere” or “forest bathing”, is an increasingly popular method of relieving stress and providing relaxation (Tsungetsugu et al. 2010).

Of the resulted 34 articles 27 were studies of physiological or psychological effects of forest on participants, 6 were reviews or summaries of studies about forests and its relation to well-being, and a summary by Kauppi et al. (2018) concluded that forest resources have increased together with human well-being.

From the 27 articles with participants as method of research, there were two types of participant groups: people for whom this forest visit was a part of rehabilitation, intervention or treatment and people who have no know underlying health condition. Out of 27 articles with study group 8 had an underlying health condition. These underlying conditions were exhaustive disorder (Sonntag-Öström et al. 2014; 2015a; 2015b), significant mental illness (Iwata et al. 2016), hypertension (Song et al. 2015), dementia (Cook 2020), chronic fatigue syndrome (López-Pousa et al. 2015) and high level of stress (Dolling et al. 2017).

Study methods were divided into physiological and psychological tests. Psychological tests were self-rated measures, such as POMS (Profile of Mod Scales), PANAS (Positive and Negative Affect Schedule) and ROS (Restoration Outcome Scale). Physiological measures were for example blood pressure, heartbeat monitoring and cortisol level from saliva sample.

Variable items were divided into two sections: visit related variables and forest stand variables. Visit variables are interlinked to an individual visit, such as number of participants, weather, season, visit length and activity performed in the forest. Forest variables were related to the forest stand in question and other spatial information, such as species composition, forest type, tree diameter, topography, and soil.

3.5 Visit variables

Visit variables described in the studies were activity in the forest, visit length, positive and negative thoughts, underlying condition, number of participants in the study, season, time of day, and weather.

In the 27 articles that included test subjects the mean number of participants was 62,6. The lowest number of test subjects was 5 in the study by Cook (2020) and the highest number was 498 in the study by Morita et al. (2006). Further test subject variables such as subject age and sex were not recorded.

Length of the forest environment visits were varying from 5 minutes (Mattila et al. 2020) to 5 hours (Wei et al. 2020). Some visits were reoccurring weekly for a maximum of 13 weeks (Iwata et al. 2016). Two of the articles with test participants did not mention the length of the visit, or it was left unclear (Zhou et al. 2019 and Cook 2020).

The most common activity in the forest environment was walking, which was described in a total of 17 studies (for example Stigsdotter et al. 2017; Takayama et al. 2014; Wang et al. 2018). Other activities performed were sitting by a fire, relaxation exercises, forest-art therapy, taking selfie-pictures in the forest and in the study by Mattila et al. (2020) study participants were viewing a virtual reality forest environment.

Other factors related to the visits were: season during the visit, which was mentioned in 19 articles, weather during the visit mentioned in 13 articles and time of the day during the visit with descriptions in 12 articles. These three variables are related to attributes such as temperature, wind velocity and relative humidity and are thus connected to the perceived quality of the visit (Zeng et al. 2020; Wei et al. 2020; Park et al. 2011).

Thoughts evoked in the forest environment were throughout the studies positive: participants described themselves feeling relaxed, soothed, peaceful or calm in 10 articles; comfortable, happiness or enjoyment in 6 articles; harmonious in 3 articles and clearheaded or invigorated in 5 articles.

3.6 Forest variables

The level of forest characterization used in the studies were universally minimal. 15 articles out of 34 (44 %) had 3 or less variable terms mentioned in the study and 5 articles (15 %) contained no mention of forest variables (for example Joung et al. 2015; Shin et al. 2010). On the opposing side, only 5 of 27 articles (19 %) with a control group and 8 out of all the 34 resulted articles (24 %) had 5 or more variables describes. Generally, characterization of forests was broad and ambiguous. For example, in the by Park et al. (2009), forest was described only as a young conifer forest. To compensate the lack of forest characterization, it was customary to provide pictures from the forest stand and possible from an urban control location such as city.

The most common forest stand related variable was species composition coming up in 22 articles out of 34 articles and the second most common was forest type with 18 hits. Other common characteristic was topography variable with hits in 12 articles. Topography is likely to be mentioned because 23 articles from 34 (88 %) included at least light activity for participants, such as walking a certain route that could have a hill or a slope. This could influence the result of the study, such as the monitored heart rate.

Age structure and closeness to a body of water were the fourth most common variables described, both with 9 hits out of 34 articles. When asked from the study participants, they would often choose forest by lake as their favourite location (Sonntag-Öström et al. 2014). Both the sound and view of water was described to have a soothing and relaxing effect on the participants (Sonntag-Öström et al. 2015a).

Stand density came up in 8 articles, climate in 7 and number of tree layers / undergrowth in 5. The amount of phytoncide in atmosphere was described in 4 articles. Phytoncides are antimicrobial allelochemicals volatile organic compounds released by plants to combat herbivore attacks and decay. There are reports of various health benefits of phytoncides, which include such as anti-fungal, anti-inflammatory, anti-microbial, analgesic, and anti-stress effect (Woo & Lee 2020).

Forest stand variables that are typical to forest inventories and forest management plans are rarely mentioned in the articles, such as height and management type both with 6 hits, diameter with 4 hits, volume with only 1 hit and amount of deadwood with 3 hits. Also, variables such as naturalness with 4 hits and biodiversity with 1 hit are relatively rare. In some cases, the information about forest stand variables might not be readily available since forests in question are urban forests (e.g., Zhou et al. 2019) or arboretum parks (e.g., Vujcic & Tomicevic-Dubljevic 2018).

3.7 The resulting health effects of the forest visits

In general, the forest environment proved to be more restorative than the urban control environment. Seasons do not matter in the case: according to a study by Bielinis et al. (2019) a recreation in snow-covered forest improves relaxation, restoration, and vitality. However, none of the studies linked a direct correlation between a forest variable and health benefit. Most of the benefits can be categorized under restorative health effects, and already a relatively short visit to a green environment starts inducing beneficial effects.

López-Pousa et al. (2015) studied the sense of well-being in patients with chronic fatigue syndrome by having an aerobic exercise program in forest environment. They came to conclusion that walking in a mature forest could decrease the subjective perception of pain and insomnia, rather than walking in a young forest.

Other improvements in health caused by the forest environment:

- Lower level of stress (e.g., Li et al. 2020, Vujcic & Tomicevic-Dubljevic 2018).
- Improved peace of mind (Sonntag-Öström et al. 2015b).
- Improved mood, mental state & cognitive performance (e.g., Shin, W. S. et al. 2010 & Mostajeran et al. 2021).
- Decreased systolic blood pressure, heart rate and cortisol level (e.g., Pagès et al. 2020; Zeng et al. 2020; Lee et al. 2010).
- Increased activity of parasympathetic nervous system (Lee et al. 2010).

- Alleviated perceived anxiety (Lee et al. 2014 & Zhou et al. 2019).
- Eases opening emotions and building rapport (Lee et al. 2020).
- Possibly enhances and activates immune response of natural killer cells (Tsao et al. 2018).

Dangers of the forest environment (Tomalak et al. 2010)

- Forest can induce allergies, fallen leaves & fruits might pose a danger as well as wild animals and unstable trees.

Some of the studies indicated certain variables having more positive or negative effect on the physiological or psychological state of the study participants.

3.8 Positive and negative forest qualities

From the 34 articles 15 described qualities that were portrayed as either positive or negative.

Some characteristics that were described having **positive** effects:

- Openness, such as a lake, mire, open tree structure provides a positive effect. It should be mentioned that a tree cover is still often desired as it offers perceived safety and privacy (Sonntag-Öström et al. 2015a).
- Light: Li et al. (2020) conducted a study comparing the effects of well-lit and dark forest scenes on research participants. The results proposed that bright sunlight scenes allay stress better than darker scenes.
- High green light spectrum ratio resulted in a higher score on the Positive Response Index (PRI) on a study by Wei et al. (2020). PRI is defined as the mean rating of four positive responses: excited, curious, interested and calm. Its opposite is Negative Response Index also known as NRI (Greene & Rosen 2019).
- Good view: a rock, eye-catching tree, lake, certain composition of trees, biological variety, etc. could provide a positive experience. This quality has a highly subjective factor as interesting or good views are dependent on personal preferences and are affected

many psychological factors, such as previous experiences. Certain views are generally more popular but random factors cannot be ruled out (Sonntag-Öström et al. 2015b).

- Forest variables such as age, density and height influenced participants' forest preferences. In a study conducted by Nordström et al. (2015) the preferred forests were a middle-aged, mature, sparsely populated lakeside pine forest and a rocky outcrop with some scattered, small, slow growing pine trees. Similar results were acquired in a study by Grilli & Sacchelli (2020) with the exception that a high-density forest caused an increase of the attention level in some study participants.
- Diverse vegetation has a positive effect according to the studies by Vujcic & Tomicevic-Dubljevic (2018), Lee et al. (2020), Iwata et al. (2016) and Zhou et al. (2019).
- Accessibility to the forest area was mentioned as a positive quality in studies by Nordstöm et al. (2015), Li et al. (2020) and Cook (2020).
- Soundscape of forest was mentioned in several articles. The lack of traffic sounds and increase in natural sounds are reported to relieve stress (Grilli & Sacchelli 2020).

Forest qualities that are described having **negative** effects:

- Closed: forests with a thick undergrowth or bush level were described to be perceived as negative qualities (Iwata et al. 2016, Sonntag-Öström et al. 2015a, Nordström et al. 2015).
- Darkness, poor visibility, and low light levels are perceived as negative qualities according to the studies by Iwata et al. (2016), Li et al. (2020) and Nordstöm et al. (2015).
- Unfamiliar looking forest locations were reported negative by study participants suffering from exhaustive disorder in a study by Sonntag-Öström et al. (2015b).
- Disorderly looking forest was mentioned in a study by Zhou et al. (2019). The description of the forest in the study didn't mention the elements that could explain the disorderly look. Possibly the

amount of deadwood on the forest floor or recently harvested forest area with some logging residue might be the cause for the reaction.

4 COMPARISON

The most notable similarity between the articles and forest recommendations was related to the openness and lightness of the forest. This quality came up in a total of 9 articles, either as a positive quality of having a good visibility and low amount of undergrowth, or as a negative mention of a dense, closed, and dark forest, especially on the bush layer. This goes well together with the recreational forest recommendations from Hamberg et al. (2012) and Komulainen (2012), but slightly against recommendations for other urban forest uses, such as protection forests. The recommendations for wind and noise protection and against marginal effect depend on having a relatively thick shrub layer and forest dominated by spruce, which usually increases the dark and closed look of a forest. On the other hand, high-density forest was mentioned to increase attention level on the participants on a study by Grilli & Sacchelli (2020).

As mentioned by Komulainen (2012) and Hamberg et al. (2012, 28-29), opening views to water is often visually beneficial. Closeness to water was mentioned as a preferred location in a quarter of the articles, as well as being often reported in self-rated measures. According to the urban forest recommendations, thinning the shrub layer near panoramic landscapes increases transparency, thus improving visual appreciation. This can have a reverse effect in industrial areas and near highways, where forests can serve as a visual cover and protection from exhaust gases and fine particles. Therefore, the location of the forest has a significant impact on the purpose of use, visual aspects, shapes, and scale of procedures (Hamberg et al. 2012, 116-117).

A positive quality mentioned in the articles was the size and thickness of the trees (Nordström et al. 2015; Grilli & Sacchelli 2020). Very similar results were found in a study by Silvennoinen (2017, 42), and the recommendations for recreational forest support similar tree qualities (Hamberg et al. 2012, 84). Although urban forest management recommendations did not specify tree species for their qualities for visual appreciation, Nordström et al. (2015) and Silvennoinen (2017, 42) found pine as the preferred tree species. A positive forest quality brought up in the study by Tyrväinen et al. (2007), which did not occur as a positive quality in the article database, was the natural look of the forests. Naturalness was reported in a total of 4 articles, but it was not linked to the positive result of the forest environment. However, quality of naturalness was mentioned in the urban forest recommendations by Hamberg et al, (2012, 34; 94-95) as a positive quality for both biodiversity as well as for recreational users.

The quality of variety and diversity in forests was mentioned as a positive variable in the articles, as well as being in accordance with urban forest recommendations. This was mentioned in studies by Vujcic & Tomicevic-Dubljevic (2018), Lee et al. (2020), Iwata et al. (2016) and Zhou et al. (2019). Komulainen (2012) mentioned that variating forest spaces to a certain degree can make the experience more interesting. This, on the other hand, is in harmony with the recommendation of maintaining biodiversity as well as the interest of recreational user by avoiding homogenous forests and increasing tree stand diversity with various tree species and trees of different ages (Hamberg et al. 2012, 36-37, 84).

Disorderly looking forest was mentioned by Zhou et al. (2019). Although it was not specified which quality made the forest look disorderly, this should be taken into consideration while planning a forest procedure. Similarly, recreational users in Finland mentioned the amount of dead wood as a negative trait (Edwards et al. 2012, 5), although it is generally considered that taking dead wood away from the forest impoverishes the soil. After management procedure felling waste is recommended to be cleaned off near busy recreation routes (Hamberg et al. 2012, 95) as it is perceived as a negative quality.

Despite Finns favoring the quality of peacefulness in the forest (Tyrväinen et al. 2007), the soundscape of the forest was hardly ever mentioned in the Finnish urban forest recommendations, whereas it was mentioned in 4 articles in relation to well-being. Hamberg (2012, 84) mentions the quality in passing by stating that a recreational user experiences the forest environment not only as visual, but also as an auditory sensation. Perhaps the amount of noise pollution is relatively low and easily escapable in in Finland?

According to the study by Anttila (2020, 12), Finnish municipalities are considering increasing the number of recreation forests, while Finnish people tend to outdoor activities in the near vicinity of their neighborhood (Hamberg et al. 2012, 24). This has the possibility to increase the social benefits gained from the forests by improving accessibility to forest, which is mentioned as a positive quality in several studies (Nordstöm et al. 2015, Li et al. 2020 and Cook 2020). This is also supported by the observation from a review by Kahn et al. (2002) that environmental interventions that support physical activity, by means of landscape planning and urban design policies, was seen as the most successful method of increasing physical activity.

Overall, the management recommendations were well analogous with the positive forest qualities from the articles (table 1).

TABLE 1. Forest qualities mentioned in the articles compared to urban forest management types.

		Management type:		
	Forest qualities:	Recreation forest	Protection forest	Nature conservation
Maintenance	General safety	Important	No mention / unimportant	No mention / unimportant
	Clearing felling waste	Depends on the location	No mention / unimportant	No mention / unimportant
	Accessibility	Important	No mention / unimportant	No mention / unimportant
Biodiversity	Naturalness	Depends on the location	No mention / unimportant	Important
	Variety	Important	Depends on the location	Important
Visual quality	Tree size	Important	Important	No mention / unimportant
	Tree species	Important	Important	No mention / unimportant
	Openness	Important	No mention / unimportant	Depends on the location
	Visibility to water	Important	No mention / unimportant	No mention / unimportant
	Soundscape	No mention / unimportant	No mention / unimportant	No mention / unimportant

Important	green
Depends on the location	yellow
No mention / unimportant	peach

5 DISCUSSION

The way forests are interpreted is slowly changing from regarding it as a timber-producing asset to recognizing the recreational and aesthetic benefits, along with conserving environmental stability and ecological systems. As the effects of forests to physical health, mental well-being and restoration are studied and getting noted, the forest management policies in state and municipality owned forests are slowly changing towards favouring non-timber production, ecology, and social benefits. Perhaps urban forests could even become a pre-emptive way to reduce modern, unhealthy living conditions and turn into a viable resource for the health care system?

The main gist of the studies was that forest environments affect us mainly positively both physically and mentally. There were, however, hardly any references to physical or mental well-being to be found in the Finnish urban forest recommendations. Understandably, the Finnish urban forest management policy goes hand in hand with the idea of introducing better accessibility, possibilities, and aesthetic attributes to increase the number of recreational users, consequently increasing well-being. It would be interesting to see health promoting natural products, which are usually known for their traditional medicinal use, utilized in a context of Finnish urban forest.

There exists a wide variety of tools to support different goals for urban forests. Despite the Finland’s law requirements to maintain social, economic, and ecological sustainability (Constitution of Finland 10 §, Local Government Act 1 § and Conservation Act 6 §), it is up to each municipality to decide for the use of their forests. This emphasizes the part of the urban forest planner, who should understand the social and economic benefits, as well as the ecological implications of forest environment, effects of each management procedure as well as support the various goals municipalities might have. Although it is more time consuming, presenting several procedure options is a good way of offering fresh ideas and uses for urban forests.

Based on the studies, visual appreciation is a highly subjective matter. Thus, the recommendations should not be too specific, but rather give general guidelines how to improve the visual aesthetics of a view. On visual and aesthetic aspects, planners should understand visual sensitivity and how to maintain a natural look of a landscape. Opening views on lakes, mires, etc. and having a relatively loose tree structure is reported to have a positive effect. Diverse vegetation increases the appreciation of the forest, which is possible to attain by growing mixed species forests and trees of different age structures.

Another factor that improves the appeal of an urban forest is its maintenance. Poorly maintained paths, thick vegetation, and the lack of signs can become a safety hazard, as well as increase the amount of litter and vandalism in the area. These, in turn, decrease the visual appreciation of the area. Therefore, it is important to assess the maintenance costs and human resource requirements when designing a green recreational area.

Ensuring the quality of easily accessible trails and exercise areas in various, aesthetically pleasing natural environments can have an impact by stimulating and motivating people to be physically more active. As mentioned in the previous chapter, municipalities in Finland are considering turning some economic forests into recreational forest, which might also increase the appeal of doing physical activities in natural environments. Providing several all-year round accessible, safe, and comfortable natural environments can promote a more active lifestyle, as it is shown in a study by Neuvonen et al. (2007).

The article search had several limiting factors, such as language barrier for studies in Asian languages. Collecting an article list from the search results was a time consuming and tedious process, as it required handling and managing a vast amount of article information. The varying level of variable terms and forest descriptions challenged identifying patterns and recognizing relationships with human health. On the other hand, health effect on the study subjects in a real-life forest exposure could be linked to numerous sensory stimuli inputs that are difficult to verify. Although the articles were theoretically from around the world, all of them were either from Europe or from Asia. Due to this, the results of the article search cannot be extrapolated to the whole world, as the forest mentioned in these articles represent only a small percentage of the world's forests. However, because of the relatively similar forest characteristics between several study locations and Finland, they can be effortlessly compared to Finnish urban forest recommendations.

A part of the theory behind urban forest recommendations can be linked to environmental psychology. There are several books and articles regarding visual appreciation of a view or studies about favorite place, and compiling information from multiple sources proved to be difficult. With only a basic understanding of environmental psychology some of the terms and theories behind studies were difficult to understand. Due to the reason mentioned earlier and the boundaries of time frame, only a limited number of environmental science articles and books could be included into thesis material. Having only a few guideline books about urban forest management and the lack of practical material led to having many references to few specific books. As some of the guidebooks were from 2012, they are also starting to become slightly outdated, and upgraded versions are currently under development.

Despite the increasing urbanisation, the health effects of Finnish urban forest are overwhelmingly positive, and the recommendations reflect well with the results of the articles. However, the connection how forest variables effect human well-being requires more studies to be understood.

REFERENCES

Anttila, T. 2020. Monitavoitteinen metsäsuunnittelu taajamametsissä – kirjallisuuskatsaus. Helsinki: Suomen kuntaliitto ry.

Bielinis et al. (2019) The Effect of Recreation in a Snow-Covered Forest Environment on the Psychological Wellbeing of Young Adults: Randomized Controlled Study. Forests. [Online] 10 (10), 827–.

Cook, M. (2020) Using urban woodlands and forests as places for improving the mental well-being of people with dementia. Leisure studies. [Online] 39 (1), 41–55.

Dolling, A. et al. (2017) Stress recovery in forest or handicraft environments – An intervention study. Urban forestry & urban greening. [Online] 27162–172.

Edwards, D. et al. (2012) Public preferences for structural attributes of forests: Towards a pan-European perspective. Forest policy and economics. [Online] 1912–19.

Grilli, G. & Sacchelli, S. (2020) Health Benefits Derived from Forest: A Review. International journal of environmental research and public health. [Online] 17 (17), 6125–.

Hamberg, L. et al. (2012) Taajamametsät: suunnittelu ja hoito. Helsinki: Metsäkustannus.

Humpel, N. et al. (2002) Environmental factors associated with adults' participation in physical activity: A review. American Journal of Preventive Medicine. [Online] 22 (3), 188–199.

Iwata, Y. et al. (2016) Benefits of Group Walking in Forests for People with Significant Mental Ill-Health. Ecopsychology. [Online] 8 (1), 16–26.

Joung, D. et al. (2015) The prefrontal cortex activity and psychological effects of viewing forest landscapes in Autumn season. International journal of environmental research and public health. [Online] 12 (7), 7235–7243.

Kahn, E. B. et al. (2002) The effectiveness of interventions to increase physical activity. A systematic review. American journal of preventive medicine. 22 (4 Suppl), 73–107.

Kaplan R, Kaplan S (1989) The experience of nature – a psychological perspective. Cambridge University Press, Cambridge.

Kauppi, P. E. et al. (2018) Forest resources of nations in relation to human well-being. PloS one. [Online] 13 (5), e0196248–e0196248.

Komulainen, M. (1995) Taajamametsien hoito. Helsinki: Metsälehti.

Komulainen, M. (2012) Metsä maisemassa: suunnittelu ja hoito. Helsinki: Metsäkustannus.

Konijnendijk, C. C. et al. (2005) Urban Forests and Trees A Reference Book. 1st ed. 2005. [Online]. Berlin, Heidelberg: Springer Berlin Heidelberg.

Kuntaliitto. Kuntametsät. Web page. Read 28.12.2021. https://www.kuntaliitto.fi/yhdyskunnat-ja-ymparisto/ymparisto/ymparistonsuojelu/kuntametsat

Lee, J. et al. (2010) Effect of forest bathing on physiological and psychological responses in young Japanese male subjects. Public health (London). [Online] 125 (2), 93–100.

Lee, J. et al. (2014) Influence of Forest Therapy on Cardiovascular Relaxation in Young Adults. Evidence-based complementary and alternative medicine. [Online] 2014834360–834367.

Lee, J. et al. (2020) Environmental influence in the forested area toward human health: incorporating the ecological environment into art psychotherapy. Journal of mountain science. [Online] 17 (4), 992–1000.

Li, C. et al. (2020) Effects of brightness levels on stress recovery when viewing a virtual reality forest with simulated natural light. Urban forestry & urban greening. [Online] 56.

López-Pousa, S. et al. (2015) Sense of Well-Being in Patients with Fibromyalgia: Aerobic Exercise Program in a Mature Forest—A Pilot Study. Evidence-based complementary and alternative medicine. [Online] 2015614783–614789.

Mattila, O. et al. (2020) Restoration in a virtual reality forest environment. Computers in human behavior. [Online] 107106295–.

Ministry of Agriculture and Forestry of Finland. Suomen metsävarat. Web page. Read 28.12.2021.
https://mmm.fi/metsat/suomen-metsavarat

Morita, E. et al. (2006) Psychological effects of forest environments on healthy adults: Shinrin-yoku (forest-air bathing, walking) as a possible method of stress reduction. Public health (London). [Online] 121 (1), 54–63.

Mostajeran, F. et al. (2021) Effects of exposure to immersive videos and photo slideshows of forest and urban environments. Scientific reports. [Online] 11 (1), 3994–3994.

Neuvonen, M. et al. (2007) Access to green areas and the frequency of visits – A case study in Helsinki. Urban forestry & urban greening. [Online] 6 (4), 235–247.

Nilsson, K. et al. (2011) Forests, Trees and Human Health. 1. Aufl. [Online]. Dordrecht: Springer Science + Business Media.

Nordström, E.-M. et al. (2015) Forests for wood production and stress recovery: trade-offs in long-term forest management planning. European journal of forest research. [Online] 134 (5), 755–767.

Ordóñez, C. & Duinker, P. N. (2013) An analysis of urban forest management plans in Canada: Implications for urban forest management. Landscape and urban planning. [Online] 11636–47.

Pagès, A. B. et al. (2020) How should forests be characterized in regard to human health? Evidence from existing literature. International journal of environmental research and public health. [Online] 17 (3), 1027–.

Park, B.-J. et al. (2009) Physiological effects of forest recreation in a young conifer forest in Hinokage Town, Japan. Silva fennica (Helsinki, Finland: 1967). [Online] 43 (2), 291–301.

Park, B.-J. et al. (2011) Relationship between psychological responses and physical environments in forest settings. Landscape and urban planning. [Online] 102 (1), 24–32.

Pearlmutter, D. et al. (2017) The Urban Forest Cultivating Green Infrastructure for People and the Environment. 1st ed. 2017. [Online]. Cham: Springer International Publishing.

Peterken, G. (1974) A method for assessing woodland flora for conservation using indicator species. Biological conservation. [Online] 6 (4), 239–245.

Schroeder, H. & Anderson, L. (1984) Perception of personal safety in urban recreation sites [Illinois, Georgia]. Journal of leisure research. [Online] 16 (2), 178–194.

Shin, W. S. et al. (2010) Forest experience and psychological health benefits: the state of the art and future prospect in Korea. Environmental health and preventive medicine. [Online] 15 (1), 38–47.

Silvennoinen, H. (2017) Metsämaiseman kauneus ja metsänhoidon vaikutus koettuun maisemaan metsikkötasolla. Dissertationes Forestales. [Online] 2017 (242).

Sjöström, M. et al. (2006) Health-enhancing physical activity across European Union countries: the Eurobarometer study. *Journal of public health*. [Online] 14 (5), 291–300.

Song, C. et al. (2015) Effect of forest walking on autonomic nervous system activity in middle-aged hypertensive individuals: A pilot study. International journal of environmental research and public health. [Online] 12 (3), 2687–2699.

Sonntag-Öström, E. et al. (2014) Restorative effects of visits to urban and forest environments in patients with exhaustion disorder. Urban forestry & urban greening. [Online] 13 (2), 344–354.

Sonntag-Öström, E. et al. (2015a) Can rehabilitation in boreal forests help recovery from exhaustion disorder? The randomised clinical trial ForRest. Scandinavian journal of forest research. [Online] 30 (8), 732–748.

Sonntag-Öström, E. et al. (2015b) 'Nature's effect on my mind' – Patients' qualitative experiences of a forest-based rehabilitation programme. Urban forestry & urban greening. [Online] 14 (3), 607–614.

Steg, L. et al. (2013) Environmental psychology an introduction. Chichester [England]; Wiley-Blackwell.

Stigsdotter, U. K. et al. (2017) It is not all bad for the grey city – A crossover study on physiological and psychological restoration in a forest and an urban environment. Health & place. [Online] 46145–154.

Takayama, N. et al. (2014) Emotional, restorative and vitalizing effects of forest and urban environments at four sites in Japan. International journal of environmental research and public health. [Online] 11 (7), 7207–7230.

Tomalak, M. et al. (2010) 'Negative Aspects and Hazardous Effects of Forest Environment on Human Health', in Forests, Trees and Human Health. [Online]. Dordrecht: Springer Netherlands. pp. 77–124.

Tsao, T.-M. et al. (2018) Health effects of a forest environment on natural killer cells in humans: An observational pilot study. Oncotarget. [Online] 9 (23), 16501–16511.

Tsunetsugu, Y. et al. (2010) Trends in research related to 'Shinrin-yoku' (taking in the forest atmosphere or forest bathing) in Japan. Environmental health and preventive medicine. [Online] 15 (1), 27–37.

Tyrväinen, L. (2001) Economic valuation of urban forest benefits in Finland. Journal of environmental management. [Online] 62 (1), 75–92.

Tyrväinen, L. et al. (2007) Luonnon merkitys kaupunkilaiselle ja vaikutus psyykkiseen hyvinvointiin. Metlan työraportteja. [Online] 52: 57–77.

Tyrväinen, L. (2020) Mitä tiedetään metsän terveyshyödyistä? Presentation. Kansanterveyttä metsästä -seminar. 5.2.2020. Tiedekeskus Heureka. Vantaa.

Ulrich, R. (1984) View through a Window May Influence Recovery from Surgery. Science (American Association for the Advancement of Science). [Online] 224 (4647), 420–421.

van der Zande, A. N. & Vos, P. (1984) Impact of a Semi-experimental increase in recreation intensity on the densities of birds in groves and hedges on a lake shore in The Netherlands. Biological conservation. [Online] 30 (3), 237–259.

Vujcic, M. & Tomicevic-Dubljevic, J. (2018) Urban forest benefits to the younger population: The case study of the city of Belgrade, Serbia. Forest policy and economics. [Online] 9654–62.

Wang, D.-H. et al. (2018) Changes in urinary hydrogen peroxide and 8-hydroxy-2′-deoxyguanosine levels after a forest walk: A pilot study. International journal of environmental research and public health. [Online] 15 (9), 1871–.

Wei, H. et al. (2020) Relationship between environmental factors and facial expressions of visitors during the urban forest experience. Urban forestry & urban greening. [Online] 53126699–.

Woo, J. & Lee, C. J. (2020) Sleep-enhancing Effects of Phytoncide Via Behavioral, Electrophysiological, and Molecular Modeling Approaches. Experimental neurobiology. [Online] 29 (2), 120–129.

Zeng, C. et al. (2020) Benefits of a Three-Day Bamboo Forest Therapy Session on the Physiological Responses of University Students. International journal of environmental research and public health. [Online] 17 (9), 3238–.

Zhou, C. et al. (2019) Effect of Short-term Forest Bathing in Urban Parks on Perceived Anxiety of Young-adults: A Pilot Study in Guiyang, Southwest China. Chinese geographical science. [Online] 29 (1), 139–150.

Zhu, S. et al. (2021) Comprehensive Evaluation of Healthcare Benefits of Different Forest Types: A Case Study in Shimen National Forest Park, China. Forests. [Online] 12 (2), 207–.

APPENDICES

Appendix 1. List of articles and variables 1(2)

Article:	Geographic focus of the study	Visit variables									Forest variable																
		activity	visit / exposure length	positive thoughts	negative thoughts	underlying cond.	nr of participants	season	time of day	weather	age structure	canopy layers	species comp	forest type	management type	naturalness	stand density / darkness	climate	topography	diameter	height	distance from water	Phytoncide	Other	positive qualities	negative qualities	reported effects on participants
Bach Pagès, A. et al. (2020)	Worldwide	(Article review)									X		X	X			X			X	X		X	Biodiversity, air quality	There might be a relationship with Systolic Blood Pressure (SBP) and mixed forest		Lower blood pressure, pulse rate & cortisol level
Bielinis et al. (2019)	Europe	Relaxation	15 min				32	X	X	X		X	X	X										Deadwood			Forest recreation in snow can increase relaxation, restoration and vitality
Cook, M. (2020)	Europe	Walking, building a bird box, planting trees, nature photography, natural artwork, willow sculpting, bird and tree identification, lighting a fire and woodland cooking				Dementia	5																		Good access and the provision of all ability trails		People with dementia found meaning in their experience and felt autonomous, retaining sense of self-worth and identity
Dolling, A. et al. (2017)	Europe	meal, relaxation exercise, undemanding activities (walking, wood cutting, relaxing, etc)	3-4 h	Relaxed, alert, happy, harmonious, peaceful and clearheaded		High stress	46	X	X				X	X				X				X					Improved mood. More relaxed, alert, happy, harmonious, peaceful and clearheaded. Levels of fatique, stress and burnout were lower
Grilli, G. & Sacchelli, S. (2020)	Worldwide	(Article review)						X	X		X		X	X			X							Deadwood	Sounds of forest help relieve stress. High density forest results in higher attention level, lower were favored in self-rated measures. Conifers and evergreens are more effective relieving stress.		Reduced cortisol level and blood pressure, effect on heartbeat, lower level of stress
Iwata, Y. et al. (2016)	Europe	Group walk	2 h / w x 13			Significant mental illness	15	X					X	X	X	X			X			X			Biological variety, quiet, beautiful	Dark, closed	Improved mood
Joung, D. et al. (2015)	Asia	Viewing	15 min	Comfortable, soothed and natural			8																				Feelings of comfortability, soothed and natural were higher in the forest environment
Kauppi, P. E. et al. (2018)	Worldwide	(Article review)														X		X	X					Disturbance, soil, volume			Positive correlation with UNDP Human Development Index
Lee, J. et al. (2010)	Asia	Observe nature while sitting and standing	30 min	Comfortable, soothed, refreshed			12							X									X				Increased parasympathetic nervous level, decreased HR & cortisol
Lee, J. et al. (2014)	Asia	Walking	2 days	Comfortable, soothed, natural			48	X	X	X			X						X								Lower HR, decrease in negative mood states and anxiety levels
Lee, J. et al. (2020)	Asia	Forest-art therapy	120 min/w x 10 weeks	Openness, free			8 per year, 2 years				X		X				X			X	X			Openness	Openness, change, diversity		Opening up (emotions) and building rapport faster, recover mental health
Li, C. et al. (2020)	Asia	Looking at a virtual reality forest	6 min				124						X								X			Maintenance, visibility, accessibility	Maintenance, visibility, accessibility, perceived safety	Low light	Bright sunlight scenes allay stress more than dark scenes
López-Pousa, S. et al. (2015)	Europe	Walking	1 h			Chronic fatique syndrome	30		X		X	X	X				X	X	X				X				Walking in a mature forest could decrease the subjective perception of pain and insomnia, rather than walking in young forest
Mattila, O. et al. (2020)	Europe	Viewing virtual reality forest environment	5 min				100		X																		VR environment could serve a restorative purpose if physical forest is not accessible. Increased positive mood, vitality and restorative outcome.
Morita, E. et al. (2006)	Asia	Walking	Mean visit duration 2 h 20 min ± 51 min				498			X																	Hostility and depression scores decresed significantly, liveliness incresed
Mostajeran, F. et al. (2021)	Europe	Looking at forest pictures and 360 forest video	6 min				35							X													Positive effect on mood, stress recovery and cognitive performance
Nordström, E.-M. et al. (2015)	Europe	(Article review)									X		X	X	X		X				X	X		Growth, mortality, deadwood, accessibility	Tree age, density and height, accessibility, the amount of distractions, random factors (solitary old tree, fallen tree, opening)	Bush layer, thick undergwoth, poor visibility and low light levels	It is possible to retain high restoration value at a relatively low cost
Park, B.-J. et al. (2009)	Asia	walking, viewing while sitting	15 min + 15 min	More calm, refreshed, comforted than in urban area			12		X					X													Forest recreation enables effective relaxation of the body and mind
Park, B.-J. et al. (2011)	Asia	Sit & view, walk	15 min + 15 min	Forest setting is more enjoyable, friendly, natural, sacred			168	X		X															Temperature, relative humidity, radiant heat, wind velocity		Positive emotions are higher in forest environment than in urban environment
Shin, W. S. et al. (2010)	Asia	(Article review)		Evokes coping behaviour, state of 'flow', tranquility and peacefulness																					Privacy, escape from crowding		Improved emotional and cognitive health
		activity	visit length	positive thoughts	egative thought	underlying cond.	nr of participants	season	time of day	weather	age structure	layers	species comp	forest type	management type	naturalness	stand density / darkness	climate	topography	diameter	height	distance from water	Phytoncide	Other	positive qualities	negative qualities	Reported effects on participants
		Visit variable									Forest variable																

2(2)

		Visit variables									Forest variable																
Article:	Geographic focus of the study	Activity	Visit / exposure length	Positive thoughts	Negative thoughts	Underlying cond.	Nr. of participants	Season	Time of day	Weather	Age structure	Canopy layers	Species comp.	Forest type	Management type	Naturalness	Stand density	Climate	Topography	Diameter	Height	Distance from water	Phytoncide	Other	Positive qualities	Negative qualities	Reported effects on participants
Song, C. et al. (2015)	Asia	Walking	17 min	Comfortable, relaxed, natural, vigorous		Hypertension	20			X			X	X					X								Lower HR, higher high-frequency component of HRV (eart rate variability)
Sonntag-Öström, E. et al. (2014)	Europe	Walking at a slow pace and sitting	10 min + 40 min	Participants experienced themselves to be most clearheaded at the lake. Environment was described as harmonious, relaxing and peaceful.		Exhaustive disorder	20	X	X	X	X		X	X					X		X	X					Forest visit was perceived as more restorative, enhancing attention capacity and mood than urban environment. Some forest environments may be more restorative than others.
Sonntag-Öström, E. et al. (2015a)	Europe	Breakfast, relaxation, other exercises	22 x 2 h	Relaxed, harmonious, peaceful		Exhaustive disorder (ED)	99	X	X	X	X	X	X	X	X		X		X			X		Open, bright, quiet	Good view, open, bright	Difficult access, no hiding places (mires)	Improved mental state, no improvement from ed
Sonntag-Öström, E. et al. (2015b)	Europe	Walk, sit, look at fire	22 x 2 h	Undemanding, peaceful, stimulating	Frustration	Exhaustive disorder	16	X			X	X	X	X	X				X			X		Light, open	Openness, light, good view	Unfamiliar	Peace of mind
Stigsdotter, U. K. et al. (2017)	Europe	Sitting & viewing, walking	Visits during 2 weeks				51	X					X			X						X					Positive effect on mood, more restorative than urban
Takayama, N. et al. (2014)	Asia	Walking and viewing	15 min + 15 min				45	X		X			X	X	X												Positive effect on mood, recovery and vitality
Tomalak, M. et al. (2010)	Worldwide	(Article review)						X					X														Forests can induce allergies, fallen leaves & fruits pose a danger, wild animals, unstable trees
Tsao, T.-M. et al. (2018)	Asia	Visit, walking exercise	5 days 4 nights				11	X		X				X	X			X									Might enhance & activate immune response NK cells
Vujcic, M. & Tomicevic-Dubljevic, J. (2018)	Europe	Spending time in forest	2 h/d, 5 weeks	Disconnected and safe, undisturbed, silent and calm			47	X						X					X					Open	"Personal corner"; open, free space; disconnected and safe; diverse; wilderness		Stress reduction and restorative experience in an arboretum
Wang, D.-H. et al. (2018)	Asia	Forest walk	2 h				28	X		X			X	X													Urinary h2o2 and 8-OHdG concentration decrease
Wei, H. et al. (2020)	Asia	Taking selfie pictures	5 h				24	X	X	X			X					X						Low noise	high green-light spectrum-ratio, low noise, higher relative humidity		Forest evoked higher happy and Positive Response Index (PRI) scores, but lower neutral scores than urban environment
Zeng, C. et al. (2020)	Asia	Sit and walk	2 x 15 min x 3 days				120	X	X	X			X			X	X		X					Light, quiet	Light, temperature, quiet		Decreased systolic bp & hr
Zhou, C. et al. (2019)	Asia	Walking, playing, eating, watching					43	X					X				X	X	X	X		X		Forest tree richness	Forest tree richness	Not orderly looking forest	Alleviates perceived anxiety
Zhu, S. et al. (2021)	Asia	(Article review)						X	X	X	X	X	X	X			X	X	X	X	X	X	X				Comfort levels were higher in the forest environment than in non-forest
34 articles	Geographic focus of the study	Activity	Visit / exposure length	Positive thoughts	Negative thoughts	Underlying condition	Nr. of participants	Season	Time of day	Weather	Age structure	Canopy layers	Species comp.	Forest type	Management type	Naturalness	Stand density	Climate	Topography	Diameter	Height	Distance from water	Phytoncide	Other	Positive qualities	Negative qualities	Reported effects on participants
		Visit variable									Forest variable																
TOTAL:		27	25	13	1	8	27	19	12	13	9	5	22	18	6	4	8	7	12	4	6	9	4		15	5	