



# **Exploring the experienced usefulness of the PSD framework in a mixed natural built environment**

– scientific literature review and on-site assessment of Henriksdalshamnen in Stockholm

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*En explorativ studie som utforskar den upplevda användbarheten av de sensoriska dimensionerna i en blandad naturlig byggd miljö – vetenskaplig litteraturstudie och platsbedömning av Henriksdalshamnen*

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Independent project in Environmental Psychology • 30 hp  
Swedish University of Agricultural Sciences, SLU  
Department of People and Society  
Outdoor Environments for Health and Well-Being; Master of Science  
Alnarp, 2022



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**Credits:** 30 hp  
**Level:** A2E  
**Course title:** Independent Project in Environmental Psychology  
**Course code:** EX1000  
**Programme/education:** Outdoor Environments for Health and Well-being  
**Course coordinating dept:** Department of People and Society

**Place of publication:** Alnarp  
**Year of publication:** 2022

**Keywords:** perceived sensory dimensions, residential area assessment, residential area planning, urban assessment, urban planning, environmental psychology

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## Abstract

As more and more people globally move to urban areas, the need to understand how people perceive the urban setting to plan and design better urban environments, that also favor general well-being among its dwellers, seems evident. This has been recognized within environmental psychology (EP) research, which has indeed aided the understanding of human perception and experience of the urban setting. However, this type of research has, according to scientific research, commonly focused on how green settings in the urban context, like parks or green spaces are perceived. This often leaves out or separates the natural from the built. Thus, tools and frameworks aimed at supporting planners, architects and designers in the urban development process have been developed exclusively for green or built environments separately. With this thesis, the focus has been put on exploring one of these existing tools called the *Perceived sensory dimensions framework* (PSD framework). Firstly, the idea was to understand if a tool that was developed to assess the perception of green areas can potentially be used favorably in a mixed natural built environment. Secondly, the objective was to explore the experience of its usefulness by looking at existing literature as well as by utilizing it in a field study in a mixed environment in order to understand if it is experienced as a useful tool for assessments of urban settings and/or in the planning process of urban environments. Thirdly, the potential advantages of this framework are discussed. The result from the literature study confirms that indeed, most scientific research involving the *Perceived sensory dimensions* (PSDs) have been utilized in green settings predominantly, but it also suggests that the PSD framework does have potential in the assessment, and possibly planning, of other settings, as the dimensions of the framework do not necessarily only relate to green space attributes or aesthetics. Furthermore, the field study confirms that the PSDs are experienced as useful in a mixed setting, but for the tool to be truly valuable for experts in urban assessment, design, and planning, continued attempts to gather and make available user experience data, and to chart applied projects and technical reports, as well as studies aiming at utilizing the tool in various settings, is desirable.

*Keywords:* perceived sensory dimensions, residential area assessment, residential area planning, urban assessment, urban planning, environmental psychology

## Preface

I was introduced to the PSD framework during a seminar in one of the courses included in the master program *Outdoor Environments for Health and Well-Being*. Although interesting, I initially found the framework difficult to grasp. Nevertheless, something about the tool sparked my interest which became the starting point of this thesis. I am an interior architect and designer myself and can thus arguably be considered an expert or professional in the field of architecture and design. I personally really appreciate frameworks and tools in my work, and I have long believed it is one of the important keys to bridging the gap between research and practice in our field. As mentioned, I had never before come across the PSD or a tool similar to it, as it seemed to be commonly tested in greenspaces rather than the built world I represent. So, as I began to comprehend the tool and its utilization within greenspace assessment, it got me wondering about its potential in other settings than green ones, settings more like the one's I work with myself. As a consequence, I decided to dive deeper into the PSDs and to experience its usefulness myself, and you are about to read what I learned and experienced.

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## Abbreviations

SLU	Swedish University of Agricultural Sciences
EP	Environmental Psychology
PSD	Perceived Sensory Dimension
PSDs	Perceived Sensory Dimensions
UGS	Urban Green Space
SPUGS	Small Public Urban Green Spaces
SET	Supportive Environment Theory
ART	Attention Restoration Theory
SRT	Stress Restoration Theory

# 1. Introduction

My own preference for certain places over others has always fascinated me. The atmosphere of a place and how that atmosphere can influence what I am feeling, thinking and how I act intrigues me.

As Seamon (2013) proclaims, by living and being in the world we are, by default, involved in people-place bonds. As a working professional in the world of design and architecture, it is of great importance to understand how users perceive an entire space or area to help guide the development of future spaces and places, to favor these bonds. By doing so we could potentially provide the best possible design solutions to, in its turn, support the general well-being of its users.

Tenngart Ivarsson and Hägerhäll (2008) argue that we need to understand e.g., the restorative possibilities of various existing environments to be able to plan and design improved environments for all, and further refer to mixed built and natural environments as an alternative to separating between natural and built contexts.

Frameworks aimed at guiding and helping city planners, architects, and designers to develop areas with the users' needs and preferences in mind do exist, but they tend to focus exclusively on natural areas or built areas in isolation (Stoltz 2020; Stoltz and Grahn 2021) and less on the entirety of urban mixed settings.

An example of what can be considered a mixed setting is a residential neighborhood which often consists of mixed natural built features. Within environmental psychology in general, there is a tendency to focus on the dichotomy between environments that are either considered natural or built (Hägerhäll, 2018; Bird and van den Bosch, 2021 see Stoltz and Grahn, 2021) and less is known about the everyday environments of people that can arguably be considered mixed natural built, like residential areas.

Today most people live in urban environments globally (United Nations, 2018; The Swedish Council for Sustainable Development, 2019), giving us reason to focus environmental psychology research on urban contexts. One might presume that urban is equal to concentrating EP research to humans and their bond or relationship to built settings, as a large part of the urban context can arguably be considered built and under human influence. But in fact, EP research within the urban context tend to emphasize settings that are considered natural, like urban green spaces (UGS), small public urban green spaces (SPUGS), or urban botanical

gardens (see e.g., Nordh et al., 2009; Grahn and Stigsdotter, 2010; Peschardt and Stigsdotter, 2013; Qiu and Nielsen, 2015; Carrus et al., 2017).

With over 74% of the European population living in urban environments (United Nations, 2018) the need to study urban settings without treating them as exclusively green or built seems evident. Indeed, extensive research shows that green and natural environments feature characteristics important to support restoration, recovery, and general well-being (Malekinezhad et al., 2020) but the everyday environment of the average human is rarely only a green and natural one. Furthermore, to be able to design and develop environments with the capability to maintain, support and restore people's general well-being, we need tools that help us evaluate the preference, perception, and invigorating capacity of present environments in their entirety and not as separate natural and built environments (Tenngart Ivarsson and Hagerhall, 2008).

## 2. Aim

The aim of this thesis is to explore the existing tool called *Perceived sensory dimensions*, also referred to as the PSDs or the PSD framework, to understand if a tool that was developed to assess the perception of green areas could be useful in a mixed natural built environment.

Additionally, the idea is to evaluate the experience of its usefulness in this type of setting. This will be done by first, looking at published scientific journal articles. Throughout this process I have learned that research and application of the tool outside of the greenspace exists, but it is not available in the scientific databases and therefore it is important to mention that applied projects or technical reports including the PSDs have not been considered in this thesis. Secondly, the tool will be tested in a field study. The hope is that this will aid the understanding of how, as an individual user, one could experience its usefulness in mixed natural built area assessment. The hypothesis for this thesis thus assumes that the PSD framework could be used to assess and evaluate mixed natural built areas, and not only natural or green ones, as the PSDs include dimensions that could arguably correlate well to a mixed setting.

Furthermore, the idea is also to discuss how the dimensions can be developed and used to guide planning and design of high quality mixed natural built areas forward, in order to stimulate the well-being of its users.

### 2.1. Research questions

1. Looking at published scientific journal articles, how has the PSD framework been described and in which environments have the PSDs been applied according to these?
2. Is the PSD framework experienced as a useful tool for environmental assessment?
3. Is the PSD framework experienced as a suitable tool for mixed natural built environments?
4. What advantages could the use of the PSDs as a tool potentially bring to professionals in the planning process of mixed natural built areas?

## 3. Perceived sensory dimensions

### 3.1. Background

To be able to motivate the choice of studying the PSDs in the context of this thesis, we need to start by outlining the background of the framework to understand it fully. Also, it is deemed important to be able to define why there could be potential for the framework for utilization in settings liked mixed natural and built ones as the *Perceived sensory dimensions* are a set of factors that have been based on human perception and processing of sensory information in, mainly, natural environments (Grahn and Stigsdotter, 2010; Stigsdotter and Grahn, 2011; Lottrup et al., 2012). Indeed, several studies suggest that there is a positive relationship between human health and sensory perception of natural environments (Dunstan et al., 2005; Grahn and Stigsdotter, 2010; Vujcic and Tomicevic-Dubljevic, 2017) making natural settings interesting to evaluate. So, to understand why these dimensions can be interesting in a mixed natural built environment, we need to explore its history and origins.

#### 3.1.1. Studies on environmental preference

To understand the history and origins of the PSDs it is valuable to mention early studies on environmental preference, as this arguably laid the foundation for contemporary studies on environmental perception. Important to mention in this context is first Appleton, as he is to be considered one of the early researchers on preference, specifically with his publication *The Experience of Landscape* (1975) where he introduced the *Prospect refuge theory* which is a theory based on the idea that there is an inherent preference to favor environments where adaptation and survival is more likely (see Hägerhäll, 2005). Secondly, Kaplan and Kaplan could also be considered forerunners in preference research and thus considered important to mention as well. Specifically, their book *The Experience of Nature* (1989b) where they describe and discuss the prediction of preference, and how landscape perception is an active process that manifests between the environment and an individual. Kaplan and Kaplan further argue in line with Appleton (1975),



suggesting that environmental preference could potentially be considered more important for survival, than the perception of what is safe and what is not.

### 3.1.2. Development of the PSDs

Several scholars propose that the PSDs are to be utilized in expert assessments of environments (e.g., Qiu and Nielsen, 2015). However, expert assessments of environments have historically often been evaluated based on featured attributes, rather than by the point of view of public preference and perception (ibid). Still, studying human sensory perception of the environment is nothing new. The PSDs specifically are, although clearly related to research by Appleton, Kaplan and Kaplan, a result of several interview studies conducted between 1985 and 2010, developing into what several researchers claim to be three generations of PSDs (e.g., Stigsdotter and Grahn, 2011; Lindholst, Caspersen and Konijnendijk Van Den Bosch, 2015; Memari, Pazhouhanfar and Nourtaghani, 2017; Malekinezhad et al., 2020).

The first generation is described to have been established by Grahn and Sorte (1985) where they investigated how parks were being utilized (e.g., Stigsdotter and Grahn, 2011; Memari, Pazhouhanfar and Nourtaghani, 2017). The second generation was established by Berggren-Bärring and Grahn (1995) where they investigated the structure of green areas, specifically urban parks, and how the users would make use of these (e.g., Stigsdotter and Grahn, 2011; Memari, Pazhouhanfar and Nourtaghani, 2017). And finally, the third generation are the PSDs introduced by Grahn and Stigsdotter (2010) as eight factors deemed to support human health and well-being (e.g., Stigsdotter and Grahn, 2011; Memari, Pazhouhanfar and Nourtaghani, 2017), see *Table 1*. With the third generation of PSDs there also seem to be a shift of focus towards understanding how the dimensions can support stress restoration (Memari, Pazhouhanfar, and Nourtaghani 2017) rather than how they support health and well-being in general.

*Table 1 The eight PSDs as described by Grahn and Stigsdotter (2010).*

<i>Dimension</i>	<i>Definition</i>
<b>Nature</b>	A factor that is described as experiencing the inherent power and force of nature, a sense of being in nature on its nature's own terms. Grahn and Stigsdotter (ibid) illustrate with the example of people performing relaxing outdoor activities, like lighting a fire.
<b>Culture</b>	A factor that contains components of human artifacts like ponds, exotic plants, statues or fountains, the essence of human culture. A factor that is connected to the need to understand human history and living conditions.
<b>Prospect</b>	This factor comprises of having open and clear vistas and views over the surroundings, exemplified by open fields and well-cut grass lawns.

<b>Social</b>	This refers to an environment that provides good potential for social activities and is illustrated by an environment with good lighting, good and clear paths where it is easy to find e.g., restrooms or seating areas
<b>Space</b>	This factor is referred to as spacious and free, specifically a green area where you should not be disturbed by too many roads or such, giving a sense of being connected.
<b>Rich in Species</b>	Here the focus is a wide variety of expressions life through, for example, different flowers, birds etc.
<b>Refuge</b>	This is described as relating to an environment that is experienced as a shelter, a safe space, and an enclosed space from where you can watch other people being active.
<b>Serene</b>	A retreat, a silent, calm and undisturbed environment where you feel safe and where there are not too many people.

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Additionally, there has, of course, been research post Grahn and Stigsdotter's article from 2010, where the PSDs have been utilized and further evaluated. An example of this is Stoltz's doctoral dissertation *Perceived Sensory Dimensions: A Human-Centred Approach to Environmental Planning and Design* (2020), where he describes the PSDs as follows:

“...a framework of eight aesthetic qualities [...] accounting for basic human needs” (p. 1)

This quote arguably highlights the universal interpretation of the PSDs, potentially more in line with earlier research on preference. Thus, it could well be interpreted as a potential suggestion for applying the PSDs not only in green areas.

Nevertheless, several studies do underline that the PSDs have roots in what is called the *Supportive environment theory* (SET) (Memari, Pazhouhanfar and Nourtaghani, 2017 see Grahn et al., 2010; Malekinezhad et al., 2020) which aims to describe the connection between the need for a supportive environment and a person's mental strength (Memari, Pazhouhanfar, and Nourtaghani 2017), as well as Kaplan and Kaplan's (1989a) *Attention restoration theory* (ART) which concerns restoring cognitively from directed attention fatigue and Ulrich's (1983) *Stress restoration theory* (SRT) which is about emotional stress restoration (see e.g., Memari, Pazhouhanfar and Nourtaghani, 2017). This could offer an explanation as to why the shift has taken a step towards focusing on environments that help people restore from a condition or mental health issue, i.e., studies greatly focusing on health care and green environments, and how these support e.g., stress restoration rather than focusing on environments that aid salutogenic principles and/or general well-being.

In fact, Grahn and Stigsdotter (2010) hypothesize that the dimensions, as described in *Table 1*, mainly relate to restoring people from stress. But in more recent studies, it has been argued that the PSDs also relate to other needs like pleasure, socializing, rest, security, and exercise (Memari, Pazhouhanfar and

Grahn, 2021), strengthening the argument that the PSD framework could potentially be an interesting tool for understanding the overall well-being of humans, and possibly in other settings than green and natural ones.

## 4. Research method(s)

The overall approach for this thesis can best be described as explorative and is further divided into two methodological parts. The first part is an extensive scientific *literature review*. Hence, focus here is put on studying a selection of published scientific journal articles involving the PSDs and specifically the attributes of each dimension, how these are described and in which environments they have been applied. Also, focus is put on how, and by who, the framework has been utilized up until now, in order to provide a basis for part two. Again, it is here important to highlight that applied projects or technical reports which utilize the PSDs are not considered.

The second part consists of a *field study*, where focus is on the experienced usefulness of the PSD framework in a mixed residential setting. This is done to be able to understand if the PSD framework is comprehended as useful for an individual expert assessment and then, how one can interpret its applicability in the process of developing mixed natural built settings, like e.g., residential neighborhoods.

### 4.1. Literature review

#### 4.1.1. Sampling

The interest and use of the PSDs in research have become gradually more significant (Memari et al., 2021) up to a point where the framework has now been applied in over sixty studies worldwide (e.g., Memari et al., 2021; Stoltz and Grahn, 2021). But, like mentioned, most of these focus on similar types of environments. Moreover, to provide a current and specific sampling for this paper, a systematic scientific literature search and review was carried out, using three different online databases (see *Appendix* for complete list of retrieved articles). The databases used were Primo, through SLU, to get an initial overview followed by Web of Science and Scopus.

### *Search 1 Primo*

The SLU Primo database was, as mentioned, used to get an initial overview of the extent of material available involving to the PSDs. To somewhat limit the search, the search was set to *Perceived sensory dimensions* with that precise phrase anywhere in the search hit. Furthermore, the search was limited to material available online, articles, material in English and peer reviewed sources which resulted in a total of 96 articles. Important to point out is that unlike the two other databases, Primo does not give the option to specify how it samples the selection made.

### *Search 2 Web of Science*

To limit the search in this database, the search topic was set to *Perceived sensory dimensions* with that exact phrase. The database then samples the chosen topic from articles that include the phrase in their title, abstract and/or as keywords. Furthermore, the search was limited to material within environmental studies, resulting in a total of 20 articles.

### *Search 3 Scopus*

Scopus works similarly to Web of Science. To limit the search in this database, the search was set to *Perceived sensory dimensions* with that specific phrase, which immediately generated 24 articles. This database also searches for the term stated in title, abstract and keywords of publications.

## 4.1.2. Analysis

When excluding doubles, the database searches described above resulted in a total of 107 unique article. This was considered too large of a sample to be able to make a thorough literature analysis given the timeframe of the project, which resulted in an attempt to further limit the sample size. This is also one of the reasons as to why applied projects and technical reports were excluded.

As Web of Science and Scopus are valued more credible databases than Primo (Kungliga Tekniska Högskolan, 2021) the articles that only occurred on Primo were excluded. Furthermore, articles that only appeared on one of the two remaining databases were also excluded, resulting in 18 remaining articles. The second step consisted of an abstract reading of the remaining 18 articles, resulting in the exclusion of nine additional articles as they were deemed irrelevant due to e.g., the environment being a non-urban setting or a too specific target group like e.g., teenagers, resulting in a remaining total of nine articles included in the final review (see *Table 2*).

### 4.1.3. Reflection

As mentioned, the search in SLUs Primo database provided a good overview of the available materials as it samples from varying databases and has therefore, in this aspect, been valued as a good starting point for the literature review in question. However, the conclusion drawn is that since Primo is a library database connected to the university, its effectiveness could be discussed as it is arguably harder to control the exact search sample and how it selects from the 63 varying sources in question (Kungliga Tekniska Högskolan, 2021).

As the Primo search result provided quite a large sample, a cross search in two of the most renowned scientific databases, Web of Science and Scopus, became appropriate to be able to limit the sample and to narrow down to the most relevant literature as well as to be able to guide the search, as the search functions and criteria provided in the latter two databases are, like already mentioned, more extensive than in Primo.

Indeed, it would have been interesting to map out applied projects and technical reports including the PSDs, but it was early deemed to be too large for the scope of this specific thesis to include.

## 4.2. Field study

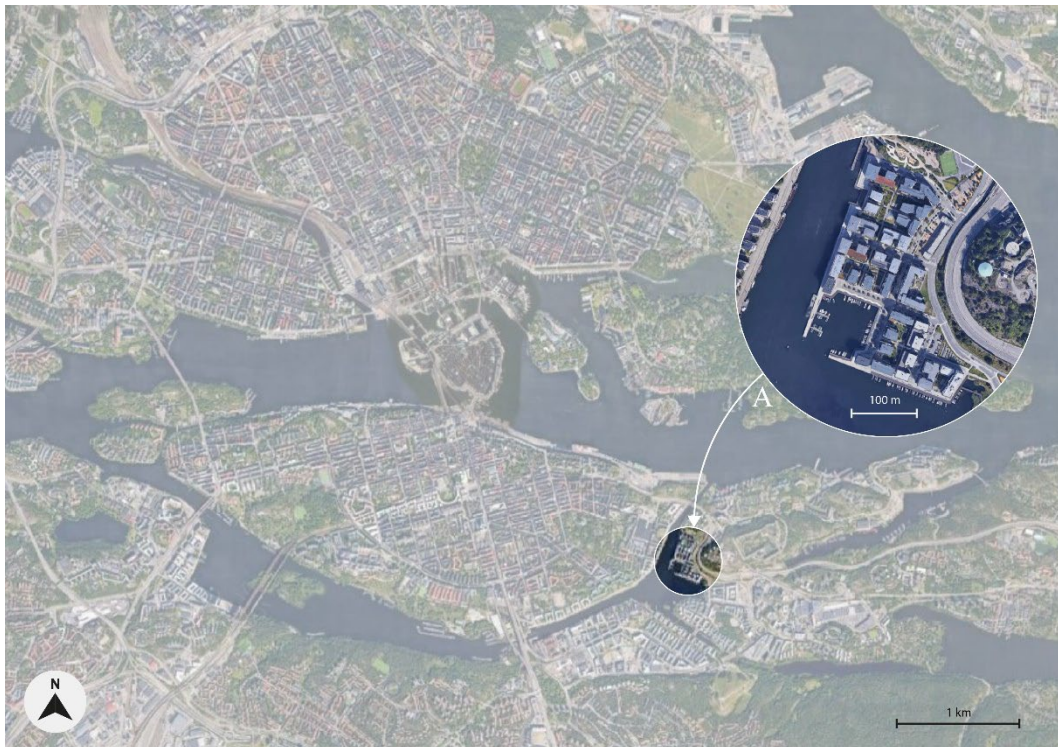
### 4.2.1. Introducing the setting

The chosen location for the field study is, of course, what can be considered a mixed natural built setting, and more specifically a residential area called Henriksdalshamnen. Henriksdalshamnen is a district of the larger area Hammarby Sjöstad, a previously industrial area that belongs to Stockholms stad municipality in Sweden, see *Figure 1* and *Figure 2* below.

Sweden can be deemed a good example when studying mixed natural built environments, as Swedish cities in general feature quite a bit of nature in built settings, both integrated by humans but also due to many cities being naturally located by e.g., sea, lake, or forest. The area of Henriksdalshamnen was specifically selected as it is considered one of Stockholm's largest contemporary residential development projects and it is also considered to have a high environmental profile (Stockholms Stad, 2021).



*Figure 1 Satellite image(s) over the Scandinavian and Baltic region (Google Maps, 2022) showing the position of Stockholm in the circle marked A (Google Maps, 2021n)*



*Figure 2 Satellite image(s) over Stockholm (Google Maps, 2021n) showing the position of Henriksdalshamnen in the circle marked A (Google Maps, 2021).*

According to Stockholms Stad (2021) Hammarby Sjöstad houses about 31 000 residents in a total of approximately 12 700 homes, also making it one of

Stockholm's largest urban development projects which further strengthens the choice of this area for the study. Specifically, the district and neighborhood of Henriksdalshamnen feature a total of 870 homes and was finalized in 2012 (Stockholms Stad, 2021). According to Iverot and Brandt (2011) 40% of Hammarby Sjöstad's total land is to be represented by courtyards, recreational grounds, and green areas highlighting the mixed nature of the area. However, as Hammarby Sjöstad is, like mentioned, developed on formerly industrial land, it features little natural integrations of greenery and nature that has not been manipulated by human influence, apart from its natural location by Hammarby lake. Thus, it is important to mention that anything from the natural world e.g., planted trees or bushes, are considered to be natural, even if they have been placed there strategically.



Figure 3 Satellite image over Henriksdalshamnen (Google Maps, 2021).

#### 4.2.2. The perspective of an individual expert

Data collection for this thesis is done through my own assessment of the environment i.e., individual expert assessment. Furthermore, this is done through the explorative use of the PSD framework using visual observation (on site and image based). The choice to provide data through individual expert assessment is partially due to the fact that the PSDs are progressively being used as a practical framework for expert evaluations of environments (Qiu and Nielsen 2015) and partially since many researchers suggest experts to use it. But, at the same time, many point out that more research is needed to validate the use and strength of the



framework in order for it to be a useful tool for experts in planning and design (e.g., Grahn and Stigsdotter, 2010; Stigsdotter and Grahn, 2011; Qiu and Nielsen, 2015; Chen, Qiu and Gao, 2019). Thus, as a possible expert user, it is of interest to take the step to experience the perceived usefulness of the tool in practice.

#### 4.2.3. Procedure

The data collection is made through physical site visits in the location of Henrikdalshammen, followed by viewing publicly available satellite images of the area to provide the experience of the setting in different seasons. Through the data gathered, the area is divided into zones which are illustrated in *Figures 5 to 14*.

#### 4.2.4. Material

From the field study, the material gathered are images taken at the sites and generated from Google which are, like mentioned, presented further in *Figures 5 to 14*. Photos have also been generated from the Google Maps satellite function. The reason for also including satellite images from Google is primarily as this thesis was written during the fall and winter, which undoubtedly affected the perception of the area and thus, it was deemed valuable to include these photos to access complementing footage.

#### 4.2.5. Analysis

After visiting the case study location on several occasions, both on site and by accessing digital sources, images were gathered, sorted, and grouped according to the zones to be further analyzed through the observation of the photos, together with the perception of the area when visiting physically. Notes were taken during the visits to be able to include these when analyzing the photos and evaluating the results.

#### 4.2.6. Reflection

The choice of studying this specific environment is mainly as explained above, but also partially due to the Covid-19 pandemic that is still widespread while this paper is being written. As the author of this thesis, I am based in Stockholm with limited and unassertive possibilities to travel given the pandemic. Hence, the study location was chosen taking into consideration that access to the study location would be ensured throughout the process. Furthermore, as mentioned prior, Sweden offers several opportunities to study mixed environments which further makes it an interesting choice of location for this paper. Hence, Sweden does provide a good starting point for studying mixed natural built settings, even if it hardly represents a global average. In fact, Swedish cities, and Sweden in general, have a low

population density compared to the global average. At the same time, the country does have most of its population living in, what can be considered, urban settings (The Swedish Council for Sustainable Development, 2019). Studying a Swedish context could therefore be deemed both an asset and limitation from a global perspective, as cities worldwide are generally more densely populated (Chen, Qiu, and Gao, 2019) and with less integration of what could be considered nature or natural although, of course, similar settings do exist outside Sweden.

## 5. Result – literature review

As mentioned prior, research aimed at understanding and specifying green area dimensions have been attempted since the mid-1980s (e.g., Malekinezhad et al., 2020; Stoltz and Grahn, 2021). However, contemporary research often fails to cover the environment that is the everyday setting for most i.e., a setting that is a mixture of what is considered natural and built (Hägerhäll, 2018) as illustrated in *Table 2* under *Setting*. All nine studies included for in-depth review have attempted to utilize the PSD framework and as showcased, urban green spaces are the most common settings out of these.

### 5.1. General overview of the PSDs

*Table 2* The articles selected from the total of 107, included in the in-depth literature review.

	<b>Name of article</b>	<b>Author(s)</b>	<b>Year</b>	<b>Country</b>	<b>Setting</b>
1	<i>The relation between perceived sensory dimensions of urban green space and stress restoration</i>	Grahn & Stigsdotter	2010	Sweden	UGS
2	<i>Perceived sensory dimensions: An evidence-based approach to greenspace aesthetics</i>	Stoltz & Grahn	2021	Sweden	UGS
3	<i>Relationship between perceived sensory dimensions and stress restoration in care settings</i>	Memari et al.	2017	Iran	Care setting
4	<i>Application of the eight perceived sensory dimensions as a tool for urban green space assessment and planning in China</i>	Chen et al.	2019	China	UGS
5	<i>Are Perceived Sensory Dimensions a Reliable Tool for Urban Green Space Assessment and Planning?</i>	Qiu & Nielsen	2015	Sweden	UGS
6	<i>Associations between park characteristics and perceived restorativeness of small public urban green spaces</i>	Pescharadt & Stigsdotter	2013	Denmark	SPUGS
7	<i>Is an environment with high biodiversity the most attractive for human recreation? A case study in Baoji, China</i>	Gao et al.	2019	China	UGS

8	<i>Associations between use, activities and characteristics of the outdoor environment at workplaces</i>	Lottrup et al.	2012	Denmark	Workplace outdoor environments
9	<i>Stressed individuals' preferences for activities and environmental characteristics in green spaces</i>	Stigsdotter & Grahn	2011	Sweden	UGS

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## 5.2. Utilization of the framework

First, these studies combinedly demonstrate that the perspective of experts using the PSD framework seems to be lacking in the available scientific literature. Most of these studies aim to include user perception in the given environment and on the specific dimensions, to justify each definition (see e.g., Qiu and Nielsen, 2015) rather than experts utilizing the framework. Additionally, several of the articles conclude with stating that development of the PSD framework as a useful tool is needed to validate its use in planning and design (see e.g., Grahn and Stigsdotter, 2010; Stigsdotter and Grahn, 2011; Qiu and Nielsen, 2015; Chen, Qiu and Gao, 2019).

Several of the dimensions presented in *Table 3* below could in theory be useful when assessing or planning a mixed natural built setting, as the descriptions of the dimensions are not necessarily solely perceived in terms of natural or green characteristics. A clear example could be the dimension referred to as *culture*. Some authors are already thinking along these lines, although a vast majority seem to include specific physical attributes. Stoltz and Grahn (2021) highlight the definition of PSDs as perceived qualities and thus, not as physical characteristics, suggestively relating back to the framework's origin in preference research, as explained prior. However, they do propose that there is a strong link between these two levels of assessments (*ibid*). Thus, to use the PSDs profitably, a revised interpretation seems needed and is suggested to be an integral part of the analysis of the *field study*.

Undoubtedly, green settings are predominant in research that includes PSDs in their exploration. As presented in *Table 2*, seven out of nine concentrates on urban green settings. Stoltz and Grahn (2021) draw the parallel between aesthetics and sensory perceptions, but focusing so heavily on green space settings and their aesthetic qualities can be questioned, as there can be doubts concerning if this really is the most essential condition to understand what makes up a satisfactory environment (*ibid*).

Grahn and Stigsdotter (2010) describe how their ambition has been to focus on the everyday situation of town dwellers, and although this is not far from the scope of this thesis, like mentioned, the everyday setting and situation of an urban resident can hardly be considered only an urban green space setting. Important to mention here is that the setting in Grahn and Stigsdotter's study is a Swedish one, and like mentioned, the urban Swedish context does vary from the average global urban

dweller, as Swedish cities generally feature more extensive natural features. This is also pointed out by Chen, Qiu and Gao (2019) who argue that current studies to a majority focus on the Scandinavian region, which suggest that they are applicable in the planning and assessment in this area, but that evidence regarding the usability of the PSDs in other regions and contexts are lacking.

Out of the articles included in the literature review Grahn and Stigsdotter's *The relation between perceived sensory dimensions of urban green space and stress restoration* (2010), which has earlier been referred to as introducing the third generation of PSDs, arguably provides the most referred to definitions of the eight dimensions (see *Table 1*). However, several of the articles included in review and presented in *Table 2* attempt at their own interpretation of the dimensions to be able to fit the context. For example, Peschardt and Stigsdotter (2013) describe how they used seven out of the eight dimensions, as one was not applicable in the study. Either this implies that the framework could be used successfully, without the application of all the eight PSDs, as Peschardt and Stigsdotter do view their results of the study as positive for future application. However, it could also indicate that the framework needs to be modified to fit the study in question. Peschardt and Stigsdotter, like several of the other authors of the papers included, do point out the need to further develop the PSDs to make them practically useful (e.g., Grahn and Stigsdotter, 2010), which further strengthens the nature of this thesis.

Another example is found in the article by Memari, Pazhouhanfar and Nourtaghani (2017) where they point out that the eight dimensions can be viewed as a fundamental starting point through combinedly offering attractive positive distractions, privacy, and natural qualities, again aiming at their own interpretation of the dimensions in the framework. The authors of the latter, also suggest that the dimensions encourage social support and physical exercise (ibid) further strengthening that the framework needs interpretation and possibly, modification to fit a given context.

Even if several studies suggest that the PSD framework could be useful for experts in evaluating and assessing a certain environment, most of the articles do not actually take on the perspective of an expert nor do they suggest how using the framework as a tool in expert assessments would be utilized in practice. Instead, the studies included in the review examine public perception of the environment in question (Stoltz and Grahn 2021) where several of these studies have acquired their data through quantitative and on-site surveys (see e.g., Stigsdotter and Grahn, 2011; Lottrup et al., 2012; Qiu and Nielsen, 2015; Chen, Qiu and Gao, 2019) using pre-coded questions (Grahn and Stigsdotter 2010). One article that stands out in this aspect provide an alternative view on expert assessments. Grahn and Stoltz (2021) discuss, in the context of estimating qualities of the urban green space, whether expert assessments are actually predictable or not, as they argue that the use of expert assessments, particularly when estimating aesthetics, can be deemed rather

unpredictable. What is also particularly interesting with Grahn and Stoltz article, is that they attempt at a rather new interpretation of the PSDs proposing a new understanding of the dimensions in a model consisting of four axes of opposing qualities (ibid).

### 5.3. A closer look at the dimensions

In *Table 3*, the PSDs as described in the nine articles of this literature study, have been summarized. The attributes marked in bold represent the understanding of the most general perception of the dimensions and are further explained and clarified in *Table 4*, to provide a common perception of the PSD framework before attempting the field study.

Several of the dimensions overlap each other and are described similarly by many of the authors, see for example the dimension *refuge* and *serene*, or *prospect* and *space*. Chen, Qiu and Gao (2019) provide some insight to this as they describe that several participants struggled with the interpretation as presented by Grahn and Stigsdotter (2010) and thus, they had to interpret and modify the description of the dimension *prospect* in their questionnaire.

Furthermore, as mentioned prior, context specific and physical attributes have been included by several of the authors, but for the continuation of the *field study* these have been excluded to use what is deemed the most common and agreed on definitions as a starting point.

ATTRIBUTES OF THE EIGHT PSDs								
ARTICLE	Nature	Culture	Prospect	Social	Space	Rich in Species	Refuge	Serene
<b>Graham &amp; Stigsdøtter, 2010</b>	<ul style="list-style-type: none"> <li>Wild</li> <li>Untouched</li> <li>Free growing lawns</li> <li>Lighting a fire</li> <li>Nature on its own conditions</li> </ul>	<ul style="list-style-type: none"> <li>Human artifacts</li> <li>Fountain</li> <li>Statues</li> <li>Exotic plants</li> <li>Ponds</li> <li>History</li> <li>Myths</li> </ul>	<ul style="list-style-type: none"> <li>Plane grass surfaces</li> <li>Well-cut grass surfaces</li> <li>Vistas over surroundings</li> <li>Open fields</li> </ul>	<ul style="list-style-type: none"> <li>Amusements</li> <li>Watching other people</li> <li>Entertainment</li> <li>Place to eat and drink</li> <li>Place for festivities</li> <li>Good paths</li> <li>Well lit up</li> <li>Easy to navigate</li> </ul>	<ul style="list-style-type: none"> <li>Spacious</li> <li>Free</li> <li>Connectness</li> <li>Not too many roads</li> <li>Not too many paths</li> <li>Non disturbance</li> </ul>	<ul style="list-style-type: none"> <li>Many species e.g., birds, flowers</li> <li>Wide range of expressions of life</li> </ul>	<ul style="list-style-type: none"> <li>Many bushes</li> <li>Equipment to play</li> <li>Watching active and playing people</li> <li>Feeling safe</li> <li>Shelter or asylum</li> <li>Enclosed</li> <li>Higher vegetation</li> </ul>	<ul style="list-style-type: none"> <li>Silent</li> <li>Calm</li> <li>Not too many people</li> <li>No noise</li> <li>No litter</li> <li>Retreat</li> </ul>
<b>Stoltz &amp; Grahn, 2021</b>	<ul style="list-style-type: none"> <li>Real wilderness</li> <li>Without human impact</li> <li>Old trees</li> <li>Naturally shaped stones</li> </ul>	<ul style="list-style-type: none"> <li>Man-made rather than self-made</li> <li>Artistic or old artefacts</li> <li>Cultivated land</li> <li>Signs of passage of time</li> </ul>	<ul style="list-style-type: none"> <li>Unified whole</li> <li>Spatial cohesion</li> <li>Unity</li> <li>Structure</li> <li>Cleared openings</li> <li>Large</li> <li>Spacious</li> </ul>	<ul style="list-style-type: none"> <li>United</li> <li>Living with others</li> <li>Not alone</li> <li>Engaging in social interaction</li> <li>Dense</li> <li>Liveliness</li> <li>Variation</li> </ul>	<ul style="list-style-type: none"> <li>Referred to as Open in this article</li> <li>Unobstructed</li> <li>Plenty of room for various activities</li> <li>Demand for views, prospects, vistas, and panoramas</li> <li>Depth of view</li> <li>Overview of surroundings</li> <li>Large</li> <li>Spacious</li> </ul>	<ul style="list-style-type: none"> <li>Diversity</li> <li>Variation</li> <li>Complexity</li> <li>Richness</li> <li>Abundance</li> <li>Denser vegetation</li> <li>Presence of trees</li> <li>Structural variations</li> <li>Biodiversity</li> </ul>	<ul style="list-style-type: none"> <li>Protection</li> <li>Variation</li> <li>Hideaways</li> <li>Varying size</li> <li>Denser vegetation</li> <li>Presence of trees</li> <li>Structural variations</li> </ul>	<ul style="list-style-type: none"> <li>Calm</li> <li>Safe</li> <li>Unaffected by noise and disturbances</li> <li>Good maintenance</li> </ul>
<b>Memari et al., 2017</b>	<ul style="list-style-type: none"> <li>Wild</li> <li>Not created by humans</li> </ul>	<ul style="list-style-type: none"> <li>Evidence of people's values, beliefs, efforts, and hard work</li> </ul>	<ul style="list-style-type: none"> <li>View that invites you to stay</li> </ul>	<ul style="list-style-type: none"> <li>Social arena</li> <li>Meeting place</li> </ul>	<ul style="list-style-type: none"> <li>Feeling of entering another world</li> </ul>	<ul style="list-style-type: none"> <li>Variety of animals</li> <li>Variety of plants</li> </ul>	<ul style="list-style-type: none"> <li>Safe</li> <li>Secluded</li> <li>A space to relax</li> </ul>	<ul style="list-style-type: none"> <li>Peaceful</li> <li>Silent</li> <li>Safe</li> <li>Secure</li> </ul>
<b>Chen et al., 2019</b>	<ul style="list-style-type: none"> <li>Wild</li> <li>Untouched</li> </ul>	<ul style="list-style-type: none"> <li>Decorated</li> <li>Fountains</li> <li>Ornamental plants</li> </ul>	<ul style="list-style-type: none"> <li>Flat lawn</li> <li>Well-cut lawn</li> <li>Scattered trees</li> </ul>	<ul style="list-style-type: none"> <li>Entertainment</li> <li>Exhibition</li> </ul>	<ul style="list-style-type: none"> <li>Spacious</li> <li>Free</li> </ul>	<ul style="list-style-type: none"> <li>Many animals</li> <li>Plants</li> </ul>	<ul style="list-style-type: none"> <li>Enclosed</li> <li>Safe</li> </ul>	<ul style="list-style-type: none"> <li>Silent</li> <li>Calm</li> </ul>
<b>Qiu &amp; Nielsen, 2015</b>	<ul style="list-style-type: none"> <li>Wild</li> <li>Untouched</li> </ul>	<ul style="list-style-type: none"> <li>Shaped by history</li> <li>Decorated</li> <li>Fountains</li> <li>Statues</li> <li>Ornamental plants</li> </ul>	<ul style="list-style-type: none"> <li>Open view</li> <li>Plane view</li> <li>Well-cut lawns</li> <li>Scattered trees</li> </ul>	<ul style="list-style-type: none"> <li>Equipped for social activities</li> <li>Entertainment</li> <li>Exhibition</li> </ul>	<ul style="list-style-type: none"> <li>Space</li> <li>Free</li> <li>Not disturbed by too many roads or paths</li> </ul>	<ul style="list-style-type: none"> <li>Wide range of expressions of life</li> <li>Many flowers</li> <li>Many animals</li> </ul>	<ul style="list-style-type: none"> <li>Space to play</li> <li>Possibility to watch other people being active</li> <li>Safety</li> <li>Benches</li> <li>Play equipment</li> </ul>	<ul style="list-style-type: none"> <li>Silent</li> <li>Peaceful</li> <li>Not too many people</li> </ul>
<b>Peschardt &amp; Stigsdøtter, 2013</b>	<ul style="list-style-type: none"> <li>Nature quality</li> <li>Wild and untouched</li> <li>Free growing lawns</li> <li>Possible to light a fire</li> <li>Not crowded</li> <li>Feels safe</li> <li>Hilly</li> </ul>	<ul style="list-style-type: none"> <li>Fountains</li> <li>Statues</li> <li>Foreign plants</li> <li>City park characteristics</li> <li>Pond, canal</li> <li>Flowers</li> <li>Wooded pasture quality</li> </ul>	<ul style="list-style-type: none"> <li>Plane, well-cut grass</li> <li>Prospect</li> <li>Cut lawns</li> <li>Football fields on grass</li> <li>Football fields on gravel</li> <li>Football fields are lit up</li> <li>Small ball grounds</li> <li>Showers, changing rooms</li> </ul>	<ul style="list-style-type: none"> <li>Entertainment</li> <li>Exhibitions</li> <li>Restaurant</li> <li>Market stalls</li> <li>Paths made of gravel</li> <li>Special park animals</li> <li>General good lighting</li> <li>Roads well lit up</li> <li>Access to restrooms</li> <li>Places sheltered from the wind</li> <li>Sunny places</li> <li>Several seats and benches</li> <li>Tables and benches</li> <li>Plenty of people</li> <li>Feels safe</li> <li>Paths with hard surfaces</li> </ul>	<ul style="list-style-type: none"> <li>Spacious</li> <li>Areas not crossed by paths</li> <li>Lots of trees</li> <li>Places sheltered from the wind</li> <li>Sunny places</li> <li>Shady places</li> <li>Plenty of people</li> <li>Feels safe</li> <li>Paths with hard surfaces</li> </ul>	<ul style="list-style-type: none"> <li>Spacious</li> <li>Areas not crossed by paths</li> <li>Lots of trees</li> <li>Places sheltered from the wind</li> <li>Sunny places</li> <li>Shady places</li> <li>Plenty of people</li> <li>Feels safe</li> <li>Paths with hard surfaces</li> </ul>	<ul style="list-style-type: none"> <li>One can detect several species of animals</li> <li>Natural plant and animal populations and pet</li> <li>Many native plants to study</li> <li>Stumps</li> <li>Tables and benches</li> <li>Watching people being active</li> <li>No traffic noise</li> <li>Play equipment</li> <li>Feels safe</li> </ul>	<ul style="list-style-type: none"> <li>Silent and calm</li> <li>No bikes</li> <li>Not crowded</li> <li>No mopeds</li> <li>Clean and well maintained</li> <li>No traffic noise</li> <li>Feels safe</li> </ul>
<b>Gao et al., 2019</b>	<ul style="list-style-type: none"> <li>Intrinsic vitality</li> <li>Inaccessible</li> <li>Wild</li> </ul>	<ul style="list-style-type: none"> <li>Cultural</li> <li>Historical</li> <li>Fountains</li> <li>Statues</li> <li>Exotic plants</li> </ul>	<ul style="list-style-type: none"> <li>Place view</li> <li>Flat and well-cut lawns</li> <li>Scattered trees</li> </ul>	<ul style="list-style-type: none"> <li>Possibility to perform social activities</li> <li>Space for gatherings</li> <li>Space for exhibitions</li> </ul>	<ul style="list-style-type: none"> <li>Lots of trees</li> <li>Connectness</li> <li>Not disturbed by too many roads or paths</li> </ul>	<ul style="list-style-type: none"> <li>Wide range of expressions of life</li> <li>Abundant flowers, birds, and butterflies</li> </ul>	<ul style="list-style-type: none"> <li>Enclosed</li> <li>Safe</li> <li>Many bushes</li> <li>Space to sit and watch other people being active</li> </ul>	<ul style="list-style-type: none"> <li>Undisturbed</li> <li>Silent</li> <li>Safe</li> <li>Space to relax</li> <li>Not too many disturbances</li> </ul>
<b>Lottrup et al., 2012</b>	<ul style="list-style-type: none"> <li>Wild</li> <li>Free growing</li> </ul>	<ul style="list-style-type: none"> <li>The experience of culture</li> <li>The experience of a lost time</li> </ul>	<ul style="list-style-type: none"> <li>Large room</li> <li>Open room</li> <li>Vast vistas</li> </ul>	<ul style="list-style-type: none"> <li>Organized for amusement</li> <li>Outdoor seating</li> </ul>	<ul style="list-style-type: none"> <li>View of a large area</li> <li>View of the sea</li> <li>View of a lake</li> <li>View of the roofs of the city</li> </ul>	<ul style="list-style-type: none"> <li>Vast variety of animals and plants</li> </ul>	<ul style="list-style-type: none"> <li>Experience of safety</li> <li>Enclosed room</li> </ul>	<ul style="list-style-type: none"> <li>Silent</li> <li>Calm</li> <li>Room to retire</li> <li>A room to be undisturbed</li> </ul>
<b>Stigsdøtter &amp; Grahn, 2011</b>	<ul style="list-style-type: none"> <li>Wild</li> <li>Free growing</li> </ul>	<ul style="list-style-type: none"> <li>Decorated with fountains and ornaments</li> </ul>	<ul style="list-style-type: none"> <li>Flat and well-cut grass surfaces</li> <li>Vistas</li> </ul>	<ul style="list-style-type: none"> <li>Entertainment</li> <li>Restaurants</li> </ul>	<ul style="list-style-type: none"> <li>Spacious</li> <li>Free</li> </ul>	<ul style="list-style-type: none"> <li>Several animals and plants</li> </ul>	<ul style="list-style-type: none"> <li>Safe</li> <li>Benches</li> <li>Play equipment</li> </ul>	<ul style="list-style-type: none"> <li>Silent</li> <li>Calm</li> </ul>

Table 3 The PSD attributes as described by the articles included in the literature review. The attributes marked in bold are the characteristics considered in the field study. These are considered open in their interpretation, and attributes that are physically descriptive e.g., benches or fountains have been excluded.

*Table 4 Definition of the eight PSDs utilized in the field study.*

<i>Dimension</i>	<i>Definition</i>
<b>Nature</b>	Perception of something wild and untouched
<b>Culture</b>	Perception of history and decoration
<b>Prospect</b>	Perception of open views and vistas
<b>Social</b>	Perception of social space and entertainment
<b>Space</b>	Perception of space and freedom
<b>Rich in Species</b>	Perception of a variety of animals and plants
<b>Refuge</b>	Perception of safety and shelter
<b>Serene</b>	Perception of silence and calm



## 6. Result – field study

As described, the objective for the field study mainly concerns the usefulness of the PSD framework and if it, in practice, is experienced as a suitable tool for individual expert assessments of mixed natural built environments. Also, the idea is to explore what the potential benefits of using the framework could be, as well as how this type of evaluation could favor the planning process for the given environment. Thus, an assessment of the environment is made with remarks regarding each dimension as an attempt at evaluating the applicability of each dimension.

As the scientific literature review suggests, the expert use of the tool seems uncommon, and there is not much inspiration on how to utilize the tool in practice. Therefore, inspiration for an expert evaluation approach is taken from the utilization of the framework in questionnaires to the public/users. A 5-point Likert scale evaluation is made for each zone where *1 = very low*, *2 = a little*, *3 = moderate*, *4 = quite high* and *5 = very high* (see e.g., Chen, Qiu and Gao, 2019).

The zoning was made to be able to evaluate the area of Henriksdalshamnen more efficiently and to aid the interpretation of results. A total score per zone as well as a total score for the whole area is presented. The zones have been divided according to the area the images were taken in (see *Figure 4*). The images included in the zoning presented have been selected randomly from a larger set of images taken on the given location of each zone. This was made in an attempt to further emphasize the natural mixed environment and thus not only assessing e.g., a park in a specific zone exclusively.

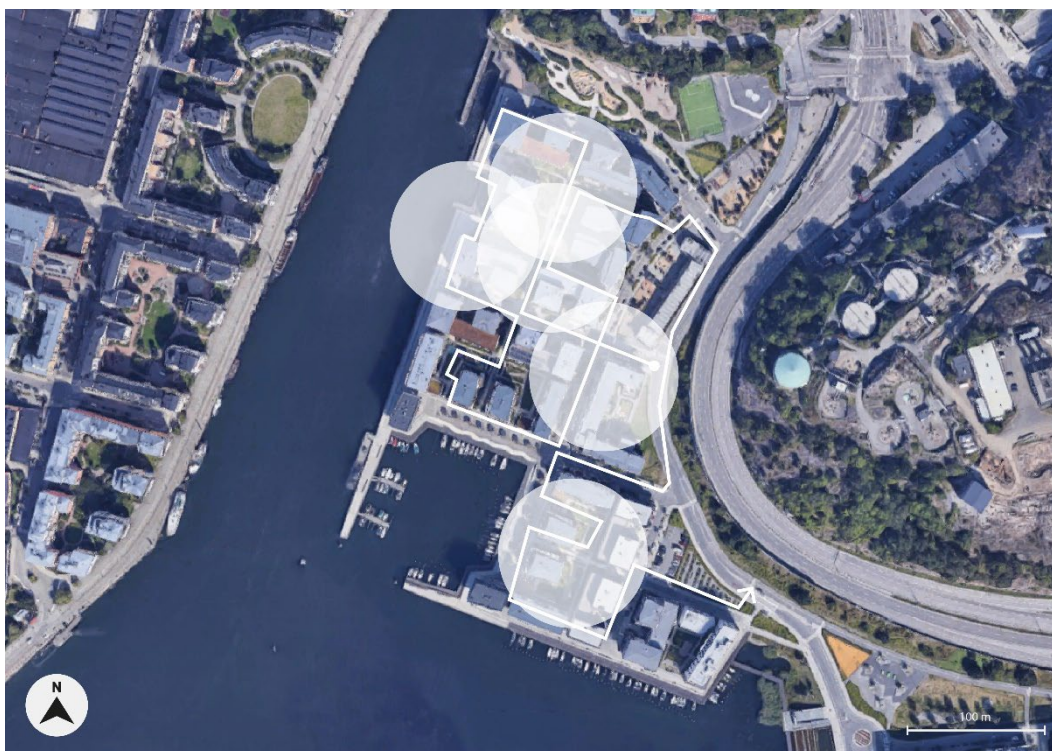


Figure 4 Overview of Henrikdalshammen (Google Maps, 2021) with all zones represented by the white circles. The walk taken during the site-visit(s) is represented by the white line where the arrow indicates direction.

	Nature	Culture	Prospect	Social	Space	Rich in Species	Refuge	Serene
Zone 1	3	2	2	3	2	2	1	1
Zone 2	2	3	4	4	4	1	2	2
Zone 3	4	2	2	3	2	3	2	2
Zone 4	2	2	1	1	2	2	3	3
Zone 5	2	1	2	1	2	1	2	2
<b>Total average:</b>	<b>2,6</b>	<b>2</b>	<b>2,2</b>	<b>2,4</b>	<b>2,4</b>	<b>1,8</b>	<b>2</b>	<b>2</b>

Table 5 Results of the assessment. Scores for all PSDs presented for each zone separately (rows 1 to 5) as well as an average for the whole area (bottom row) calculated on the scores for all zones.

## 6.1. Assessment Zone 1



Figure 5 Overview of Henriksdalshamnen (Google Maps, 2021) with Zone 1 represented by the white circle.

In all the panels presented in *Figure 5*, there are natural elements present. However, the nature that exists can hardly be interpreted as untouched as it has clearly been placed there by humans. In terms of wild, one might argue that the natural elements present are in some senses wild. For example, *Panel F* showcases a plantation that although clearly placed there by humans, can be perceived as *moderate* wild vegetation.

The perception of culture in this zone scores a 2, i.e., *a little*. Decoration can be perceived in *Panel F* in the form of what seems to be a statue. History might not be as evident, but there are signs of historical presence in the form of e.g., cobble stones covering several of the streets, see *Panels B, D* and *F*. A last remark regarding culture is that the choice of colors on facades might originate in colors found in historical building around Stockholm and could arguably therefore be considered somewhat a connection to culture. However, if this is something that a user would perceive as culture is debatable.

In terms of prospect, there is depth of field between roads providing somewhat open views and vistas, but it scored a 2 and thus as perceiving only *a little* of the dimension prospect. Space is valued similarly as there is the feeling of space between streets, but hardly the feeling of freedom as one is surrounded by buildings throughout this zone.

When it comes to the dimension social, the presence of restaurants and public spaces in the lower parts of the buildings contribute to the perception of social space and entertainment. As can be seen in *Panel A* and *B*, the presence of humans also contributes to this perception. In *Panel C* to *F*, there are not many humans present. In fact, during the physical visits on site there were not many people going around in the area and most likely, this is due to the fact that visits to Henriksdalshamnen were made during fall and winter, as well as during the pandemic which inevitably affects this dimension. In fact, this area is considered lively and busy of social activity and entertainment during spring and summer months (Stockholms stad 2017) which illustrates that the assessment will probably differ depending on season.

The perception of being an environment rich in species is also affected by seasonal change. For example, *Panel C* and *E* feature trees but it is difficult to evaluate which species of tree these are, given the fact they have shed their leaves for the winter. Nevertheless, the other vegetation present in other panels showcase some perception of variety, mainly in color and thus, this dimension is valued to 2 i.e., *a little*.

Refuge and serene are considered non-apparent.



Figure 6 Images taken in the area represented in Figure , Zone 1. Panel A (Google Maps, 2021b) and Panel B (Google Maps, 2021c) are digitally sourced, and all other images are taken by the author.

## 6.2. Assessment Zone 2



Figure 7 Overview of Henriksdalshamnen (Google Maps, 2021) with Zone 2 represented by the white circle.

Regarding *Zone 2*, presented in the panels in *Figure 7*, the presence of nature is evident from water and trees, but hardly wild. The presence of water could be interpreted as somewhat untouched and hence, the perception of nature scores to *a little* on the Likert scale evaluation.

Culture scores a 3 i.e., *moderate* on the Likert scale since, like mentioned earlier, there are cobblestoned streets but also due to the presence of vegetation in an evidently decorative aspect, and lastly due to the industrial nature of the location which becomes more evident in this zone close to the water.

The presence of water also contributes to the experience of open views, vistas, space and freedom and thus prospect and space scores a 4 i.e., quite *high*.

As there are benches, restaurants and office spaces in this zone, the social dimension scores a 4 as well.

The perception of a variety of animals and plants is non-evident and thus, the dimension rich in species each score 1, which on the Likert scale implies *very low*.

The perception of refuge and thus safety and shelter scores *a little* in the evaluation. Mainly, the possibility to sit under trees by the water could be experienced as sheltering.

The water contributes to the dimension serene, as its mere presence has a calming effect.



*Figure 8 Images taken in the area represented in Figure 7, Zone 2. Panel A (Google Maps, 2021h) and Panel B (Google Maps, 2021d) are digitally sourced, and all other images are taken by the author.*

### 6.3. Assessment Zone 3



Figure 9 Overview of Henriksdalshamnen (Google Maps, 2021) with Zone 3 represented by the white circle.

Zone 3 has the highest rating of nature, mostly as seen in *Panel A* and *B*. Like the other zones, most nature here is placed by humans, but the presence of water and the fact that the nature in *Panel A* can be considered somewhat wild, this has been rated as the zone with the highest scoring perception of nature.

The distribution and placement of the nature that does exist here, are perceived as quite decorative and thus the culture dimension scores as *a little*. In *Panel E*, one can also see a house in a neighboring area which is far older and thus further include the dimension of culture, specifically history.

Prospect and space are both valued at 2, mainly as a result of the water and vegetation as can be seen in *Panel A* and *B*. *Panel E* also gives a certain feeling of an open view between the houses.

The social aspect here is mainly represented by the playground which is located in one of the courtyards in the area. What is interesting in Henriksdalshamnen, is that the courtyards are accessible for anyone to enter which in some ways give the perception of an environment that is open, social and free. However, some might feel that this has rather the opposite effect, which is why the dimensions refuge and space have also been valued 2 on the Likert scale.

When it comes to rich in species, the abundance of nature gives the perception of a variety of vegetation which is why this dimension is valued 3 and thus, moderate.





*Figure 10 Images taken in the area represented in Figure 9, Zone 3. Panel A (Google Maps, 2021e) and Panel B (Google Maps, 2021g) are digitally sourced, and all other images are taken by the author.*

## 6.4. Assessment Zone 4



Figure 11 Overview of Henriksdalshammen (Google Maps, 2021) with Zone 4 represented by the white circle.

Similarly to *Zone 3*, the dimension of culture is partially represented by the views of an older area that can be seen in *Panel C*. *Panel C* is also the only view that give a bit of space in this zone.

Refuge and serene are valued the highest overall in this zone, but again this could be paradoxical as the perception of safety and shelter is based mainly on *Panel D* and *E*, but for some this type of passage could rather be viewed as unsafe and scary to pass in, which indicates that its perception it is largely dependent on who assesses the environment.

The perception of this zone being rich in species is mainly, like mentioned prior, due to the abundance of colors in the actual vegetation that is present, but it is still valued as rather little in terms of variety.

The dimension of serene is mainly perceived in terms of the space feeling silent and calm during the physical visits, and thus illustrates the multi-sensory aspect when experience the environment physically.

Prospect and social are assessed as 1 and thus *very low*.



Figure 12 Images taken in the area represented in Figure 11, Zone 4. Panel A (Google Maps, 2021f) is digitally sourced, and all other images are taken by the author.

## 6.5. Assessment Zone 5



Figure 13 Overview of Henriksdalshamnen (Google Maps, 2021) with Zone 5 represented by the white circle.

Generally, this zone was experienced as detached from the rest of the area. You can sense that it is in the end of Henriksdalshamnen. Not a lot of people passing, houses are to a majority painted in white, black, and gray. The perception of refuge and serene is quite contradictory because although it feels silent and quite sheltered, this area does not feel very safe.

Furthermore, culture and thus history and decoration, have been valued as the lowest overall. Same goes for the dimensions social and rich in species. All other dimensions score a 2 on the Likert scale, and thus are perceived as *a little*.



*Figure 14 Images taken in the area represented in Figure 13, Zone 5. Panel B (Google Maps, 2021m) and Panel C (Google Maps, 2021k) are digitally sourced, and all other images are taken by the author.*

## 7. Discussion

The overall aim of this thesis has been to understand the application, description, and use of the PSDs as outlined in the scientific literature. With the knowledge gained from the scientific literature review, it has also been to explore the experienced usefulness of the framework as an individual expert, in order to understand and test its applicability in the assessment of mixed natural built environments. Additionally, it has also been to understand the dimensions' potential advantages in the practice of planning and designing high quality mixed natural built areas.

This thesis merely scratches the surface of how the PSDs can be used, experienced and applied, specifically as it presents the understanding of one single individual. What has also become clear is that the applied projects and technical reports that feature the PSDs, should undoubtedly be reviewed in a possible continuation of this thesis, as the published scientific journal articles leave out important perspectives. Nevertheless, with the work reviewed in this thesis the conclusion is that the PSDs are suitable for mixed natural built environments, but how the overall tool and its dimensions need to be developed in order to favor urban planning and design specifically, is still not entirely clear. Furthermore, the results are discussed in relation to each aim below.

*Aim 1: Looking at published scientific journal articles, how has the PSD framework been described and in which environments have the PSDs been applied according to these?*

The studies examined in the scientific literature review illustrate a tool highly useful for green area assessment, with little information regarding its applicability in alternate settings. Scholars find consensus in the fact that there is a positive relationship between human health and sensory perception of natural environments (Dunstan et al., 2005; Grahn and Stigsdotter, 2010; Vujcic and Tomicevic-Dubljevic, 2017) again highlighting the focus that predominantly concentrates on the context and exploration of green settings. What evidently seems to be lacking in this literature are descriptions and reasoning on how to practically use the framework. To illustrate with an example, the assessments that are mentioned in this specific literature, treat featured attributes of an environment (Qiu and Nielsen 2015) rather than the perception of a setting as an entity. Therefore, it is also

difficult to answer how the framework has been applied in practice. Also, most data that feature user perception and not expert perception, although several articles make the claim that it is indeed a useful tool for experts in environmental assessments.

Furthermore, although applied in various environments in several different studies with differing goals, the predominant trend is clearly its application in green settings (see e.g., Stigsdotter and Grahn, 2011; Chen, Qiu and Gao, 2019; Gao et al., 2019; Stoltz and Grahn, 2021). This seems to have its reason in the fact that EP research have, to a majority, focused on natural aspects of environments in general. Also, reason seems to stem from the latest generation of PSDs, as proposed by Grahn and Stigsdotter (2010), which refer to the frameworks advantage in natural settings and have been referred to extensively in the included literature.

Although research shows that there are, of course several positive aspects of evaluating green environments, the everyday environment of the average global citizen is not exclusively green nor natural. This thus supports the development of tools withing EP aimed at evaluating mixed built natural environments, rather than only green ones, to be able to provide better quality everyday environments to favor general well-being for all. In fact, this has already been acknowledged in more recent works, but those have, like mentioned, not been included in this study as they have not been available in the scientific journals that have been sourced.

*Aim 2: Is the PSD framework experienced as a useful tool for environmental assessment?*

With the field study, one can argue that it showcases that the framework is useful to the extent that it can be used by one individual, working professional in the field of design and architecture, who interprets the environment according to the dimensions as outlined in *Table 4*. Then, some might argue that more descriptive instructions on how to use the tool in professional practices would be needed for the PSDs to become truly useful, even if that does not necessarily have to be the case, as others might reason that kind of development of the framework would limit the role of experts in urban planning and design. Thus, the individual experience of the tool in the field study settles that although useful, it likely needs further utilization and consideration to become a truly beneficial tool for environmental assessment.

Even if the focus of this question is the experience gathered from the field study, it is deemed valuable to also mention aspects concerning the tools usefulness assembled from the scientific literature review. Not rarely, scholars in the featured articles suggest that the PSD framework is indeed a useful tool for professionals in urban assessment and development, but there seems to be little evidence that the framework has actually been tested or used by professionals in practice. Especially when it comes to environments that are not only green. Furthermore, the

professional assessments that are mentioned in the scientific literature, treat featured attributes of an environment (Qiu and Nielsen 2015) rather than the perception of a setting as an entity.

Additionally, it is difficult to answer how the framework has been applied by experts in practice, as most data that can be reviewed feature user perception and not expert perception. But again, applied projects or technical reports are not considered here, which would potentially suggest otherwise.

*Aim 3: Is the PSD framework experienced as a suitable tool for mixed natural built environments?*

The studies revised in the scientific literature review find consensus in the fact that there is a positive relationship between human health and sensory perception of natural environments (Dunstan et al., 2005; Grahn and Stigsdotter, 2010; Vujcic and Tomicevic-Dubljevic, 2017). Thus, one might wonder why a tool like the PSDs, developed for natural settings, could be applicable in a mixed context when the reviewed works clearly point in the direction of nature settings. Although this must be further investigated, the potential partially lies in the history of the PSD framework, which indicates that the framework was firstly developed out of general preference research and secondly, as the development of the framework and its natural interpretation can be favorable for mixed environments. For example, the perception of the dimension of nature, does not necessarily have to feature real nature, as long as its perception and experience is of a natural one to its user. Similar arguments are made by Stoltz (2020) in his doctoral thesis, strengthening this perspective.

The practice of biophilic design (Kellert and Calabrese 2015) offer further explanation of this approach, as the authors argue that indirect experiences of nature might be as valuable to the impact an environment has on its user. To justify with an example from Kellert and Calabrese's publication, an interpretation or experience of nature could be the one of a natural color which in practice, is not a direct feature of nature, but could be explained as contributing to the experience of a natural environment (ibid).

Additionally, in the assessment of *Zone 1*, the social dimension is represented by the presence of for example, restaurants or children's playgrounds. According to the definition given in *Table 4* the dimension social can be perceived as social space and entertainment, which evidently a restaurant would offer. This does not necessarily include any actual characteristics of nature or what can be considered green, which indicates potential for the tool in mixed natural built environments.



*Aim 4: What advantages could the use of the PSDs as a tool potentially bring to professionals in the planning process of mixed natural built areas?*

This is not entirely easy to answer as this thesis represents the experienced usefulness of one individual user. Thus, if it was to be carried out by another professional within the field of urban planning, design or architecture, the answer to this question might or might not vary. Nevertheless, from the data gathered in the scope of this thesis and the perceived use of the tool in the field study, perhaps the most obvious advantage would be the integration of features in an environment known to support human well-being, like the integration of what is perceived as nature or natural (see for example Dunstan et al., 2005; Vujcic and Tomicevic-Dubljevic, 2017).

Although ambiguous, the use of this tool in the planning process of a mixed natural built setting could possibly aid the salutogenic aspects of general well-being among the users i.e., residents of a residential neighborhood.

Furthermore, this aim also proves difficult to answer due to the fact that the tool has been used to assess an already existing environment. Perhaps, the tool is better suited to evaluate already developed areas than as a tool to be used in the planning and developing phase of new areas. If it were to be utilized as a tool in the planning stage of an area, where no physical settings could be analyzed prior to its development, one idea would be to carry out photo-elicitation analysis of photorealistic renderings, models, or such. Although such an approach would need more careful consideration before being tested in practice.

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Google Maps (2022) Stockholm's position in the Scandinavian and Baltic region.

[figure] Available at:

[https://www.google.com/maps/place/Stockholm/@58.582499,14.734940,7,1442650m/data=!3m1!1e3!4m5!3m4!1s0x465f763119640bcb:0xa80d27d3679d7766!8m2!3d59.3293235!4d18.0685808>](https://www.google.com/maps/place/Stockholm/@58.582499,14.734940,7,1442650m/data=!3m1!1e3!4m5!3m4!1s0x465f763119640bcb:0xa80d27d3679d7766!8m2!3d59.3293235!4d18.0685808)

## Acknowledgements

I would like to direct a thank you to my supervisor, Caroline Hägerhäll.

## Appendix

Name of article ( <i>107 articles in total</i> )	Author(s)	Year	Primo ( <i>96 articles in total</i> )	Web of Science ( <i>20 articles in total</i> )	Scopus ( <i>24 articles in total</i> )
<b>1</b> Forest design for mental health promotion—Using perceived sensory dimensions to elicit restorative responses	Stigsdotter et al.	2017	x	x	x
<b>2</b> The relation between perceived sensory dimensions of urban green space and stress restoration	Grahn & Stigsdotter	2010	x	x	x
<b>3</b> How perceived sensory dimensions of urban green spaces are associated with teenagers' perceived restoration, stress, and mental health?	Akpinar	2021	x	x	x
<b>4</b> Perceived sensory dimensions: An evidence-based approach to greenspace aesthetics	Stoltz & Grahn	2021	x	x	x
<b>5</b> Perceived sensory dimensions of green areas: An experimental study on stress recovery	Memari et al.	2021	x	x	x
<b>6</b> Relationship between perceived sensory dimensions and stress restoration in care settings	Memari et al.	2017	x	x	x
<b>7</b> Application of the eight perceived sensory dimensions as a tool for urban green space assessment and planning in China	Chen et al.	2019	x	x	x
<b>8</b> Are Perceived Sensory Dimensions a Reliable Tool for Urban Green Space Assessment and Planning?	Qiu & Nielsen	2015	x	x	x
<b>9</b> Investigating the Mental Health Impacts of University Campus Green Space Through Perceived Sensory Dimensions and the Mediation Effects of Perceived Restorativeness on Restoration Experience	Malekinezhad et al.	2020	x		x
<b>10</b> Associations between park characteristics and perceived restorativeness of small public urban green spaces	Peschardt & Stigsdotter	2013	x	x	x



11	The Effects of Artificial Lake Space on Satisfaction and Restorativeness of the Overall Environment and Soundscape in Urban Parks	Qi et al.	2021	x		
12	The effects of urban natural environments on preference and self-reported psychological restoration of the elderly	Qiu et al.	2021	x		x
13	The restorative potential of icelandic nature	Kristjansdottir et al.	2020	x		x
14	What characteristics of urban green spaces and recreational activities do self-reported stressed individuals like? A case study of Baoji, China	Gao et al.	2019	x		x
15	The qualities of natural environments that support the rehabilitation process of individuals with stress-related mental disorder in nature-based rehabilitation	Pálsdóttir et al.	2018	x	x	x
16	The impact of nature on creativity – A study among Danish creative professionals	Plambech & van den Bosch	2015	x	x	x
17	Is an environment with high biodiversity the most attractive for human recreation? A case study in Baoji, China	Gao et al.	2019	x	x	x
18	Associations between use, activities and characteristics of the outdoor environment at workplaces	Lottrup et al.	2012	x	x	x
19	Stressed individuals' preferences for activities and environmental characteristics in green spaces	Stigsdotter & Grahn	2011	x	x	x
20	The influence of forest resting environments on stress using virtual reality	Wang et al.	2019	x		
21	Exposure to neighborhood green space and mental health: Evidence from the survey of the health of wisconsin	Beyer et al.	2014	x		
22	Beyond greenspace: An ecological study of population general health and indicators of natural environment type and quality	Wheeler et al.	2015	x		
23	Measurement, Collaborative Learning and Research for Sustainable Use of Ecosystem Services: Landscape Concepts and Europe as Laboratory	Angelstam et al.	2013	x		
24	Green qualities in the neighbourhood and mental health - Results from a longitudinal cohort study in Southern Sweden	Annerstedt et al.	2012	x		
25	Social and Cultural Sustainability: Criteria, Indicators, Verifier Variables for Measurement and Maps for Visualization to Support Planning	Axelsson et al.	2013	x		
26	Urban green space perception and its contribution to well-being	Kothencz et al.	2017	x		

27	A different way to stay in touch with 'Urban Nature': The perceived restorative qualities of botanical gardens	Carrus et al.	2017	x
28	Solving Problems in Social–Ecological Systems: Definition, Practice and Barriers of Transdisciplinary Research	Angelstam et al.	2013	x
29	Is variety the spice of life? An experimental investigation into the effects of species richness on self-reported mental well-being	Wolf et al.	2017	x
30	Longer nature-based rehabilitation may contribute to a faster return to work in patients with reactions to severe stress and/or depression	Grahn et al.	2017	x
31	Profiles of nature exposure and outdoor activities associated with occupational well-being among employees	Hyvönen et al.	2018	x
32	Classification of the tree for aerial image using a deep convolution neural network and visual feature clustering	Lin et al.	2019	x
33	The journey of recovery and empowerment embraced by nature - Clients' perspectives on nature-based rehabilitation in relation to the role of the natural environment	Pálsdóttir et al.	2014	x
34	A diagnostic post-occupancy evaluation of the Nacadia® therapy garden	Sidenius et al.	2017	x
35	What flowers do we like? The influence of shape and color on the rating of flower beauty	Hûla & Flegr	2016	x
36	Beneficial Health Outcomes of Natural Green Infrastructure in Cities	McKinney & BerBerkmoes	2020	x
37	'Everything just seems much more right in nature': How veterans with post-traumatic stress disorder experience nature-based activities in a forest therapy garden	Poulsen et al.	2016	x
38	Area-aggregated assessments of perceived environmental attributes may overcome single-source bias in studies of green environments and health: Results from a cross-sectional survey in southern Sweden	De Jong et al.	2011	x
39	Exploring inter-rater reliability and measurement properties of environmental ratings using kappa and colocation quotients	Björk et al.	2014	x
40	The Affective Quality of Human-Natural Environment Relationships	Hinds & Sparks	2011	x
41	Residents' Self-perceived Health and its Relationships with Urban Neighborhood Green Infrastructure	Mansor et al.	2015	x
42	Healthy Architecture! Can environments evoke emotional responses?	Roessler	2012	x

43	Planning for restorative forests: describing stress-reducing qualities of forest stands using available forest stand data	Stoltz et al.	2016	x
44	The wildman programme. A nature-based rehabilitation programme enhancing quality of life for men on long-term sick leave: Study protocol for a matched controlled study in Denmark	Høegmark et al.	2020	x
45	Restorative effects of multi-sensory perception in urban green space: a case study of urban park in Guangzhou, China	Zhang et al.	2019	x
46	The influence of viewing photos of different types of rural landscapes on stress in Beijing	Wang et al.	2019	x
47	Exploring psychophysiological restoration and individual preference in the different environments based on virtual reality	Gao et al.	2019	x
48	Investigating the qualities of a recreational forest: Findings from the cross-sectional hallerwald case study	Cervinka et al.	2020	x
49	Moving to serene nature may prevent poor mental health— results from a swedish longitudinal cohort study	van de Bosch et al.	2015	x
50	REVIEW: Quantifying urban ecosystem services based on high-resolution data of urban green space : An assessment for Rotterdam, the Netherlands	Derkzen et al.	2015	x
51	The influence of audio-visual interactions on psychological responses of young people in urban green areas: A case study in two parks in China	Zhang et al.	2019	x
52	Experiences of the urban green local environment as a factor for well-being among adults: An exploratory qualitative study in southern Sweden	Weimann et al.	2019	x
53	Exploring the perceived restorativeness of natural soundscapes under the global pandemic of COVID-19: A moderated mediation model	Qiu et al.	2021	x
54	The regenerative compatibility: A synergy between healthy ecosystems, environmental attitudes, and restorative experiences	Giusti et al.	2020	x
55	The relationship between natural park usage and happiness does not hold in a tropical city-state	Saw et al.	2015	x
56	Relationships between characteristics of urban green land cover and mental health in U.S. metropolitan areas	Tsai et al.	2018	x

57	From economic survival to recreation: Contemporary uses of wild food and medicine in rural Sweden, Ukraine and NW Russia	Stryamets et al.	2015	x
58	The contribution to stress recovery and attention restoration potential of exposure to urban green spaces in low-density residential areas	Huang et al.	2021	x
59	Benefits of a three-day bamboo forest therapy session on the psychophysiology and immune system responses of male college students	Lyu et al.	2019	x
60	A systematic review and meta-analysis of associations between green and blue spaces and birth outcomes	Akaraci et al.	2020	x
61	Compact and green urban development-towards a framework to assess urban development for a high-density metropolis	Fan et al.	2019	x
62	Residential greenspace and urban adolescent substance use: Exploring interactive effects with peer network health, sex, and executive function	Mennis et al.	2021	x
63	Regulating and cultural ecosystem services of urban green infrastructure in the nordic countries: A systematic review	Amorim et al.	2021	x
64	The analysis of green areas' accessibility in comparison with statistical data in poland	Wysmulek et al.	2020	x
65	Experiencing nature to satisfy basic psychological needs in parenting: A quasi-experiment in family shelters	Peters et al.	2020	x
66	Comparisons of landscape preferences through three different perceptual approaches	Gao et al.	2019	x
67	Designing urban green spaces for older adults in asian cities	Tan et al.	2019	x
68	A systematic review and meta-analysis of nature-based mindfulness: Effects of moving mindfulness training into an outdoor natural setting	Djernis et al.	2019	x
69	Does digital nature enhance social aspirations?: An experimental study	van Houwelingen-Snippe et al.	2020	x
70	Determining urban open spaces for health-related appropriations: a qualitative analysis on the significance of blue space	Völker et al.	2016	x
71	Improved Wellbeing for Both Caretakers and Users from A Zoo-Related Nature Based Intervention-A Study at Nordens Ark Zoo, Sweden	Sahlin et al.	2019	x

72	From nature-based to nature-driven: Landscape first for the design of moeder zernike in groningen	Roggema	2021	x
73	Understanding green street design: Evidence from three cases in the u.s	Rodriguez-Valencia & Ortiz-Ramirez	2021	x
74	A critical review on the impact of built environment on users' measured brain activity	Azzazy et al.	2021	x
75	Physiological and Psychological Effects of Nature Experiences in Different Forests on Young People	Liu et al.	2021	x
76	Biophilic design for restorative university learning environments: A critical review of literature and design recommendations	Peters & D'Penna	2020	x
77	Study of the cooling effects of urban green space in Harbin in terms of reducing the heat island effect	Huang et al.	2018	x
78	The naturalness of the Vistula Riverbank's landscape: Warsaw inhabitants' perceptions	Wojnowska-Heciak	2019	x
79	Mapping urban park cultural ecosystem services: A comparison of twitter and semi-structured interview methods	Johnson et al.	2019	x
80	Green spaces in residential communities: the potential for ecological and health	Abass	2021	x
81	Using Nature-Based rehabilitation to restart a stalled process of rehabilitation in individuals with Stress-Related mental illness	Sahlin et al.	2015	x
82	I can hear the birds: using audio recordings to assess perceptions of amenity in urban riparian environments	Corney & Neave	2018	x
83	Exploring associations of housing, relocation, and active and healthy aging in sweden: Protocol for a prospective longitudinal mixed methods study	Zingmark et al.	2021	x
84	Differences of Restorative Effects While Viewing Urban Landscapes and Green Landscapes	Kang & Kim	2019	x
85	Nature as a mental health intervention: State of the science and programmatic possibilities for the conservation community	Reuben & Himschoot	2021	x
86	Nature-based stress management course for individuals at risk of adverse health effects from work-related stress-effects on stress related symptoms, workability and sick leave	Sahlin et al.	2014	x

87	Perceived loudness sensitivity influenced by brightness in urban forests: A comparison when eyes were opened and closed	Hong et al.	2020	x	
88	The effects of open space on reducing workplace stress: Case study of business park in the post-socialist urban setting	Maric et al.	2021	x	
89	Differently Designed Parts of a Garden Support Different Types of Recreational Walks: Evaluating a Healing Garden by Participatory Observation	Tenngart Ivarsson & Grahn	2012	x	
90	Applying the concept of perceived restoration to the case of Cheonggyecheon Stream Park in Seoul, Korea	Kim et al.	2017	x	
91	Applying the benefits of biophilic theory to hospital design	Totaforti	2018	x	
92	Perception of Green Open Space as Medium of Therapy for Elderly	Darmawati et al.	2019	x	
93	Empirical analysis on the determinants of urban parks	Shimamoto	2019	x	
94	Sensory basis of refreshing perception: Role of psychophysiological factors and food experience	Labbe et al.	2009	x	
95	Experiences of Women with Stress-Related Ill Health in a Therapeutic Gardening Program	Eriksson et al.	2011	x	
96	Forests for wood production and stress recovery: trade-offs in long-term forest management planning	Nordström et al.	2015	x	
97	Tourists' memories, sensory impressions and loyalty: In loco and post-visit study in Southwest Portugal	Agapito et al.	2017		x
98	Perceiving resilience: understanding people's intuitions about the qualities of air, water, and soil	Satterfield et al.	2018		x
99	"Sensing" the destination: Development of the destination sensescape index	Buzova et al.	2021		x
100	Aesthetic value of nature - Pleasure or appreciation?	Parizkova & Stibral	2013		x
101	Environmental tastes, opinions and behaviors: social sciences in the service of cultural ecosystem service assessment	Katz-Gerro & Orenstein	2015		x
102	A Study on How the Five Senses Are Affected When Tourists Experience Towns with Forest Characteristics: An Empirical Analysis Based on the Data of Fujian, Guangdong and Sichuan in China	Shao & Lin	2021		x
103	The significance of natural and serene environment to improve the quality of living in tiny homes	Zainal & Aziz	2021		x

<b>104</b>	Study on the relationship between the restorative effect of urban green space and personal environmental preference A case study of the Longtan park in Taiyuan	Zhihao	2021	x
<b>105</b>	From research to practice: Operationalisation of the eight perceived sensory dimensions into a health-promoting design tool	Stigsdotter et al.	2020	x
<b>106</b>	The serene and other affordances in parks in Demanding urban contexts	Skärbäck et al.	2015	x
<b>107</b>	Landscape characteristics in Tartu City Parks: User influences through design	Maikov	2013	x

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