Relationship of trees as green infrastructure to pro-environmental behavior for psychological restoration in urbanized society: a systematic review

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Abstract. The need for green infrastructure has increased with the awareness towards a sustainable environment. Trees are considered one of the "green infrastructure" elements due to the "green" benefits they have provided to the urban environment. Greener environments are associated with mental health, and to the urban inhabitants, trees bring a multitude of environmental benefits. Even though there are various opinions on pro-environmental behavior (PEB), there are similar understandings of protecting and preserving the environment. Psychological Restoration (PR) is a cognitive progression in replenishing a good emotion via a connection with the natural environment and urban park. This paper reviews the literature published between 2005-2021 on SCOPUS and describes the current knowledge regarding PEB and PR connected to urban trees. Preferred reporting items for systematic reviews and meta-analyses known as PRISMA were employed, which deals with identification, evaluation, exclusion, and inclusion of data. Some studies have focused on how the natural environment can affect human health and well-being. Other studies have looked into the built environment and considered urban trees as a positive solution to stress alleviation and social cohesion. Hence, the reviews will provide a proposition for future research in the respective field to yield relevant results to the societies.

1. Introduction

Green infrastructure has received much attention in decades due to its dynamic properties, which offer essential social growth development benefits. Green infrastructure is a system of multifunctional green space that promotes natural and ecological processes that are critical to human health and quality of life. Social functions of green infrastructure have often been investigated, improving mental and physical
health [1]. Besides that, it has been found many green infrastructure components have been identified for green infrastructure system application. The components consist of core elements, including urban trees [2]. Urban trees, for example, provide a variety of chances to mitigate negative consequences such as climate change while also providing human health and well-being to modern city dwellers [3]. However, although demonstrated the impact of the urban trees on increased quality of life over decades, the concept of psychological restoration (PR) in urbanized societies with urban tree contribution has received little consideration. The questions remain, what are the current knowledge regarding Pro-Environmental Behaviour (PEB) and PR connected to urban trees. Hence, additional study of the relationship of urban trees to PEB for PR in urbanized society is needed.

This paper aimed to review the literature published between 2005-2021 on SCOPUS and describe the current knowledge regarding PEB and PR connected to urban trees. It presents PRISMA, a suggested reporting item for reviews and meta-analyses in a systematic that focuses on data identification, evaluation, exclusion, and inclusion. Based on these reviews, it specifically focuses on the urban tree attributes that are contextual to the urbanized society to provide outcomes that are both scientifically and practically interesting to society. The paper begins by concisely defining the key terminology (‘green infrastructure’, ‘urban tree’, ‘pro-environmental behavior’, ‘psychological restoration’ and, ‘urbanized society’), followed by an explanation of the methods applied. Results of the systematic exploratory review are then reported and discussed. Some recommendations are made for future research.

2. Trees as a green infrastructure component

Some studies on the green infrastructure component have defined what is meant by the term ‘urban tree’ and ‘green infrastructure’ [2, 3, 4, 5]. Green infrastructure makes cities and towns more livable, and urban trees are an integral part of it. They are woody perennial plants that appear in urban areas [6]. Individual urban trees grow on public and private property, in residential areas, along roadways, parks, and commercial development, as well as trees growing in stands within a city. If trees are planted at a global average density in all urban areas around the world, they have the potential to hold 121 billion trees [7]. They make a great contribution to human well-being since they are a well-known green infrastructure component, especially when they can stimulate pro-environmental engagement in urban life. The word "urban tree" here refers to a growth form rather than a vegetation type, so defining the study's focus.

While [8] have defined pro-environmental behavior (PEB) as “activities that reduce the negative impact on (such as preserving and preventing damage to), and, or encouraging enhancements to, the natural and the built world”, this definition is simultaneously too comprehensive and too restrictive for this paper. PEB in this study is a term referring to: “People who are characterized by mindfulness as a trait feel more connected to nature and engage more in environmental protection”. PEB has a particular appeal among outdoor recreationists; when they are encouraged in recreationally used environments, they grasp the ability to mitigate anthropogenic stressors [9]. These allow people to relieve psychosocial stress, socialize, relax, and connect with nature and outdoor leisure in order to improve their well-being and generate pleasant emotions [10].

For instance, environmentalists have recognized the significance of urban trees in psychological restoration (PR) among urban citizens that face a psychological problem impact from rapid urbanization. A psychological problem comprises stress, anxiety, and depression create distress and a negative impact on daily human life [11]. The factors refer to overcrowding, lacking infrastructure, poor quality housing, joblessness, social mistrust, and crime [12]. A group of urban trees could improve mental health by promoting comfortable outdoor physical or social activities that increase community interaction and reduce crime [13, 14].

Despite the high intensity of scholarly interest, the literature does not provide a thorough overview of current information regarding PEB and PR in relation to urban trees. In the PEB and PR literature, there hasn't been any work on a preferred reporting item in systematic reviews and meta-analyses (PRISMA) of urban trees. Thus, this study fills in the knowledge gap.
3. Methods
A preferred reporting item for systematic reviews and meta-analyses (PRISMA) was performed using a methodology extensively used in the health and social sciences [15]. The identification of resources was initiated by searching the literature via the Scopus database published within 2005-2021 (figure 1). The combination of terms was used to explore the research in accordance with “Green Infrastructure”, “Pro-Environmental Behaviour”, “Psychological Restoration”, “Urban Trees”, and “Well-Being” keywords. Each article has mined for information on the GI components associated with PEB and the PR impact. By systematically searching the relevant literature, such reviews deliver identification, evaluation, exclusion, and inclusion of the current status of a field of research.

4. Results
4.1. Study selection
The study reviewed 30 Scopus articles. Figure 2 summarizes the study selection process, whereas Figure 3 details the Scopus database query string. Between 2005 and 2021, 140 publications were found through a literature search using Scopus databases and search engines. Despite mentioning the terms “green” and "tree" in their titles, abstracts, and keywords, 108 were eliminated since they were not in the field of green infrastructure and urban tree study. The remaining 32 articles' entire texts were thoroughly scrutinized, and two of them were eliminated because they did not meet the eligibility criteria. For instance, one article study on green building innovations [16]. Another article looked at forest management [17]. There were only 30 articles left from 20 different journals.
Figure 2. The study selection approach is depicted graphically in this flow chart.

Figure 3. Scopus database query string.

4.2. Study characteristics
Table 1 lists the study characteristics that were included in the review.

4.2.1. GI component and PEB investigation. While most (n=19) of the studies explored types of tree, nine studies [18, 19, 20, 21, 22, 23, 24, 25, 26] did an urban tree space consideration, relating the character of urban tree attributes for PEB and PR respectively. Except for two studies from Germany [27] and New Zealand [28] were exploring tree planting activities.

Studies (n=11) described the tree species in the tree type category for PEB. They reported that the native trees [29], ornamental trees [32, 33, 34], street trees [33], and forest trees [34, 35, 36, 37, 38] among popular tree species typically reported for satisfaction, attraction, feeling, preferences,
experience, and memories that motivated factors for PEB. Four tree types studies [28, 29, 30, 31] demonstrated that large tree sizes influence PEB. Using an interview [30, 32] and experiment [39] method, highly valued and higher satisfaction assessed the impact from the large tree size. Although the tree species and the tree size demonstrated influencing PEB, the quantity of tree affects as well [43]. Moreover, on the aesthetic features, the tree with a diversity of flowers significantly increased the humans’ preferences and drew attention to nature's connection [33, 34].

The studies specified that the green space [18, 19, 21, 23, 24, 26], natural space [20], and urban park [22, 25] as space consideration on trees related to PEB. [18, 19, 20] reported a tree in green and natural space promoted physical activities. Moreover, [24, 25] mentioned the trees increase the quality of space and motivate people to spend more time in natural and urban parks covered by trees. The studies on the tree planting activities toward the PEB context are very limited. [28] found residents involved more in planting scheme and surrounded by high trees density shows more heightened PEB awareness. Only one study discovered the subject of PEB on the human–food connection (HFC), which is similar to the tree planting activities that is the urban gardening [27]. Surprisingly, the reports from this research emphasize the PEB on external body-related (immediate urban garden-body activities: experiencing food contact and food harvesting) and internal mind-related (experiential food interaction and food harvesting) activities (immediate urban garden-mind activities including food discovery and food consciousness).

4.2.2. PR impact. All studies concluded that urban trees as GI components effectively promote PR for urban society. In physical health, [20] found a decrease in mental distress as well as a reduced risk of negative mental health, such as reduced systolic and/or pulse pressure [39] and restorative effect [46]. Meanwhile, in the perspective of psychology, [21, 30, 33, 35, 45] reported the association of PEB for psychological restoration was associated with reduced anxiety, tension, confusion, and fatigue. Some studies (n=5) differentiated the PR impact based on a positive view of a point such as life satisfaction and positive feelings [19], a stronger sense of self [34], vitality and positive affect [31], positive mood, and desire to help others [41], and psychological–social resistance and resilience [38]. One study contrast to others, reports on the angle of economic aspect. [42] described the PR impact through planting program involvement increased per capita monthly household income.

4.2.3. Summaries of the main result. This systematic review identified 30 studies to provide current evidence for an urban tree as a green infrastructure component increasing PEB for PR among urban society. 19 (66.33%) studies focused on tree type of either the species, size, or aesthetic. 9 (30%) studies explore the urban tree space consideration and present the green space, natural space, and urban park promoting the PEB. Only 2 (6.67%) studies demonstrated the tree planting activities related to PEB. These explained people whose exposure to tree-planting schemes and urban gardening activity delivers PEB.

Table 1. The articles' characteristics of the included reviews.

| Author               | Year | Subject                                                                 | Urban Tree, PEB & PR Investigation                                                                 |
|----------------------|------|-------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| Artmann et al.[27]   | 2021 | Urban gardening is a technique of promoting an embodied human–food relationship in the city. A case study on urban vegetable gardens was conducted. | GI Component: Urban gardening PEB factor: Body and mind-based nature connections                       |
| Jones B A[42]        | 2021 | Improve the quality of life. City trees are being planted. Impacts of urban afforestation on life satisfaction. | GI Component: Mature urban forest (size) PEB factor: Level of satisfaction (interview) PR impact: Increase per capita monthly household income |
| Andrade et al.[29]   | 2021 | Neighborhood satisfaction and yard management decisions are influenced by landscape preferences. | GI Component: Trees and native plants (species) PEB factor: Level of satisfaction                    |
different restorative effects.

- Anxiety.

In urban parks on young people.

A pilot study in Guiyang, Southwest China, looked at the effect of short-term forest bathing in urban parks on young people's reported anxiety.

Viewing urban and green surroundings has different restorative effects.

| Author et al. | Year | Subject | Urban Tree, PEB & PR Investigation |
|---------------|------|---------|-----------------------------------|
| Kabisch et al.[39] | 2021 | A field investigation in a crowded inner-city region looked at the physiological and psychological impacts of visits to varied urban green and street environments on elderly individuals. | GI Component: Widespread and old trees (size) PEB factor: Naturalness and restoration experience (experiment) PR impact: Decreases in systolic blood pressure and pulse pressure |
| Van Vliet et al.[44] | 2021 | User preferences and the impact of urban park attributes: An online stated-choice experiment was used to assess virtual parks. | GI Component: Flower trees (aesthetic) PEB factor: Human preferences |
| Ugolini et al.[18] | 2020 | An international exploratory investigation of the effects of the COVID-19 pandemic on the utilization and perceptions of urban green space. | GI Component: Greenspace PEB factor: Physical exercise, relaxing and observing nature |
| Jahani et al.[30] | 2020 | Environmental modeling approach applied to aesthetic preference and mental restorative prediction in urban parks. | GI Component: Ornamental trees (species) PEB factor: Attraction PR impact: Recover mental stresses |
| Veitch et al.[40] | 2020 | A qualitative study employed walk-along interviews to design parks for older folks. | GI Component: Established trees (size) PEB factor: Valued (interview) |
| Suárez et al.[43] | 2020 | Environmental justice and outdoor leisure opportunities in the Oslo metropolitan region, Norway: A spatially explicit assessment. | GI Component: High density of trees (quantity) PEB factor: Accessible & opportunities |
| Gagliardi et al.[19] | 2020 | Preliminary results of an Italian initiative on the benefits of elderly persons participating in environmental volunteering and socializing activities in city parks. | GI Component: Green spaces PEB factor: Physical activity, PR impact: Life satisfaction and positive feelings |
| Campagnaro et al.[45] | 2020 | In the historic city of Padua, green places are preferred for stress release and perceived safety (Italy). | GI Component: Sparse flower trees (aesthetic) PEB factor: Preferences (safety) PR impact: Stress relief |
| Birch et al.[34] | 2020 | How urban nature helps young people's mental health and well-being in a diverse UK metropolis. | GI Component: Natural/forest trees (species) PEB factor: Feelings of escape PR impact: A stronger sense of self |
| Whitburn et al.[28] | 2019 | The connection to nature, the use of nature for psychological restoration, and environmental attitudes are all linked to pro-environmental behavior when exposed to urban nature and tree planting. | GI Component: Tree cover PEB factor: Participation |
| Elsadek et al.[33] | 2019 | A field experiment in Shanghai looked at the impact of urban roadside trees and their physical context on stress alleviation techniques. | GI Component: Street trees (species) PR impact: Reduced tension, fatigue, confusion, and anxiety |
| Rugel et al.[20] | 2019 | An urban region's exposure to natural space, sense of community belonging, and negative mental health effects. | GI Component: Natural space PEB factor: Physical activity PR impact: Reductions in psychological distress and reduced odds of negative mental health |
| Suppakittpaisarn et al.[47] | 2019 | Preference is predicted by the density of green infrastructure. | GI Component: All types and vegetation density (species) PEB factor: Preferences. |
| Zhou et al.[35] | 2019 | A pilot study in Guiyang, Southwest China, looked at the effect of short-term forest bathing in urban parks on young people's reported anxiety. | GI Component: Urban forest (species) PR: Decline of anxiety |
| Kang et al.[46] | 2019 | Viewing urban and green surroundings has different restorative effects. | GI Component: Natural scene PR impact: Restorative effect |
Further studies are required to determine the specific type of tree projected to the specific psychological distress within urban society. This has been proved by a study [24], people spend more time with the greenspace, urban park, and natural area for outdoor activities. Interestingly, although the particular sites indexed as higher greenspace neglect, the index was unrelated.

5. Discussion
The relationship of urban trees as green infrastructure components to PEB for PR toward urban society is yet to be fully elucidated. Urban tree plays a wide variety of roles in human mental and physical health, especially for urban society. Recent studies have shown that contact with the urban tree can reduce psychological distress [39] and increase psychological restoration [21, 30, 33, 35, 45]. The species, size, and aesthetic features of the tree were found to be translated into satisfaction, attraction, feeling, preferences, experience, and memories for PR incorporated into PEB. However, rapid urbanization inflicted urban stressors such as overcrowding, lacking infrastructure, poor quality housing, joblessness, social mistrust, and crime [12] that affect the lives of the city. Thus, further studies are required to determine a specific type of tree projected to the specific psychological distress within urban stressors.

The potential space by which urban tree promotes PEB outcomes is shown in figure 4. Although the specific activities by which urban society becomes PR by PEB remain undetermined, the urban tree space consideration is found will increase the PEB awareness. This has been proved by a study [24], people spend more time with the greenspace, urban park, and natural area for outdoor activities. Interestingly, although the particular sites indexed as higher greenspace neglect, the index was unrelated.
to tree cover [24]. However, more research on the specific behaviors of PEB promoters is needed to help guide the establishment of urban tree programs in greenspace, urban parks, and natural areas.

From the viewpoint of tree planting activities, a potential alternative source for viable, practicing PEB would be from a different individual exposed to tree-planting schemes and urban gardening participation. [28] investigated at a tree-planting scheme that was linked to PEB patterns. Their results demonstrated that there is a strong association between tree-planting participation with engagement in PEB. In the same finding [27] on their urban gardening study added, engagement in PEB needs the local-body (urban garden-body activities) and mind-based (urban garden-mind activities) nature connections for fostering earth stewardship. Thus, the findings demonstrated above align with understanding urban trees improving mental and physical health by promoting comfortable outdoor physical or social activities [13, 14].

| Tree Space Considerations | PEB Factors |
|---------------------------|-------------|
| Urban Park                | Subjective Norm |
| Natural Area              | Quality of Space |
| Greenspace                | Physical Activities |
|                           | Preferences |
|                           | Number of Trees |

Figure 4. The space consideration for PEB engagement.

6. Strength of the review
The fact that this study is the most recent systematic review to present evidence regarding the relationship of trees to PEB for PR in urbanized society is a notable strength of this analysis. This review performed a comprehensive search from the Scopus database that is the largest and most reputable academic literature.

7. Limitation of the review
The current review has two limitations. First, as the concept of green infrastructure is well established, this review should acknowledge the significant possibility of other studies published in other languages. This review may have missed potentially relevant literature. Second, due to the small number of articles included, this review did not undertake a quantitative meta-analysis. Thus, the data synthesis is primarily descriptive.

8. Conclusion
In the present review, we have summarised the relationship of trees to PEB for PR in urbanized society. PEB engagement variables in the context of urban tree features and contributions to PR were demonstrated in the research included in our analysis. The results presented support the benefit of urban tree contributions on PR in PEB engagement, but research on the topic is still extremely limited. Therefore, further in-depth investigations are required, especially in specific types of trees and activities promoting PEB to improve PR outcomes.
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