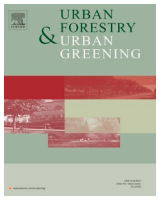
Urban Forestry & Urban Greening 101 (2024) 128494

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug



Review article

Investigating school ground vegetation research: A systematic mapping review

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ARTICLE INFO

Keywords:
School ground vegetation
School ground greening
Urban greening
Children's environments

ABSTRACT

Vegetation on school grounds has several values and functions that contribute to aspects as children's well-being, pedagogy and microclimate among others. Research on school ground vegetation is conducted within many different research fields and deals with a variety of research themes. A systematic review was conducted to explore scientific literature on the topic of school ground vegetation broadly, enabling an overview of this diverse field and the discovery of trends or gaps within this research. The objective was also to investigate to what extent actual vegetation is in focus in this literature. The results highlight a low level of specificity when describing vegetation, concerning both spatial aspects and content, with general terms such as "nature" or vegetation types (trees/shrubs/grass, etc.) being common, leading to difficulties in interpretation and synthesis. A multitude of themes are present, describing different research foci. Several themes show limited interaction with other themes, such as the theme "microclimate", which may be of notable relevance for future research because of global warming. More coherence in how to describe vegetation on school grounds is needed to compare results. Also, more connections between research themes could address research gaps and be beneficial for future research endeavours.

1. Introduction

Children spend a considerable part of their time in child-care institutions and educational facilities, environments that therefore have a great possibility to influence their daily lives (van Dijk-Wesselius et al. 2018, Lindemann-Matthies and Kohler, 2019). School-based greenness has been shown to be of great benefit to children in several ways, including positively affecting academic performance (Browning and Rigolon, 2019), environmental relationships and overall well-being (Puhakka et al. 2019). School ground vegetation has also been shown to be attractive to children and may result in more gender-equal play (Lucas and Dyment, 2010). Another important aspect of green spaces in educational environments is thermal comfort. Exceedingly hot outdoor temperatures affect the amount of usable space on school grounds as well as the health of the children and possible pedagogical activities (Bäcklin et al. 2021). In urban areas, vegetation may provide shade and thereby cooling, making the environment more comfortable (Antoniadis et al. 2020). Beyond its direct benefits to children, urban school vegetation also contributes to broader environmental goals. Vegetation on school grounds can serve as green stepping stones and thereby enhance green connectivity in urban areas (Iojă et al. 2014). Such green spaces may moreover serve as habitats for various species, thus promoting urban biodiversity as well as enabling species' movement across urban areas (Muvengwi et al. 2019).

The connections described above have been found largely because of the research made concerning school ground vegetation. The arguments for researching school ground vegetation often centre around the vegetation's positive impact on children (Sylvia, 2010, Moore et al. 2015, Paddle et al. 2016, Luis et al. 2020), but the types of research conducted have many different foci and belong to various research fields, such as landscape architecture (Jansson et al. 2014), biology (Muvengwi et al. 2019), education (Janet, 2004) and health (Nury et al. 2017).

The latter years have included an increased focus on school ground greening both in research and in a multitude of school ground development projects and organisations across the globe. An example of a recently initiated project is the Oasis project in Paris (European Environment Agency, 2022). Started in 2019 the project goal is to rebuild the school grounds of Paris in order to meet the challenges of climate changes with higher temperatures and extreme weather events. A big focus in this project is on implementing school ground vegetation.

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https://doi.org/10.1016/j.ufug.2024.128494
Received 22 March 2024; Received in revised form 23 August 2024; Accepted 25 August 2024
Available online 31 August 2024

Another example from Europe is the Forest school project, where the focus has been on increasing outdoor learning in the UK by for example implementing wooded outdoor classrooms (The Mersey Forest, 2024). In the United States, the non-profit organization Green Schoolyards America has been dedicated to implementing and promoting greener school grounds since its founding in 2013 (Green Schoolyards America, 2024). Similar school ground greening projects have been initiated for several decades and the projects themselves have been the topic for research (Dyment and Reid, 2005, Sterling, 2005, Giezen and Pellerey, 2021).

The width of research fields involved in the topic of school ground vegetation also demonstrates that vegetation on school grounds is expected to fill several functions. Multifunctionality, as defined by the Landscape Institute (2009) concerning the role of urban vegetation, refers to the capability of a given area to provide a variety of functions, delivering benefits that are societal, environmental, and economic. This expected multifunctionality of school ground vegetation has been highlighted within the topic of school ground greening (Iojă et al. 2014, Syed Ayub et al., 2015).

Multiple reviews have already been conducted concerning children and vegetation. Some of them focus on the effect of vegetation on cognitive aspects and academic performance (Browning and Rigolon, 2019, Mason et al. 2022, Vella-Brodrick and Gilowska, 2022) or physical activity and other aspects connected to health (Trost et al., Ye et al. 2022). Focus on how vegetation affects children's development and children's experiences of nature also occur (Islam et al. 2020, Bakri and Aoul, 2021, Sakhvidi et al. 2022). Many previous reviews focus on learning environments specifically (Trost et al. 2010, Browning and Rigolon, 2019, Bakri and Aoul, 2021, Mason et al. 2022). There is, however, a lack of overview of all research that has been conducted concerning vegetation on school grounds across research fields and foci. Whether geared towards enhancing educational outcomes, promoting environmental awareness, or exploring the level of biodiversity, the aims of the different studies within this topic serve as a driving force behind the research. Understanding these aims may provide an in-depth picture of the research made and reveal patterns, overlaps, and research gaps. There is no existing review, to the knowledge of the authors of this paper, which has been made with the purpose of mapping all scientific literature concerning school ground vegetation, independent of field or research foci.

An essential factor in analysing research on school ground vegetation concerns the attributes surrounding the vegetation itself. The term vegetation encompasses everything from perennials to trees, spanning complex plant systems, monocultures, solitary trees and shrubs (Merriam-Webster.com, 14 Dec 2023). In order to effectively connect and apply research findings on the impact of school ground vegetation on children and the environment, it is of value that vegetation is well described in studies, where the level of specificity in the description of the vegetational content and the spatial characteristics of vegetated areas can be helpful. Additionally, there is a need to recognise that vegetation is dynamic and changes over time (Gustavsson, 2004). It is therefore of interest to examine if the literature explores the vegetation both in detail and across a timespan.

School grounds are utilised by a diverse range of age groups, spanning from preschool children to high school students. This wide age range significantly influences the utilisation and, by extent, requirements of the vegetation present in these areas as the age of children has been shown to affect how they interact with vegetation (Jansson et al. 2014). Consequently, research focusing on the need for vegetation among 10-year-olds may not be relevant or applicable to 16-year-olds, given the distinct differences in their requirements. Therefore, it is essential to conduct comprehensive research on vegetation on school grounds catering to all child age groups. Exploring the distribution of existing studies on school ground vegetation across age groups is thus of specific interest.

Understanding the global context is crucial as well, as it encompasses cultural, geographical, and climatic factors that shape these environments. The impact of school ground vegetation on children has been shown to depend on the design and management of school grounds (Malone and Tranter, 2003), processes themselves heavily influenced by prevailing policy frameworks and governance structures (Randrup et al. 2020). These structures dictate the resources allocated for the creation and management of such green spaces, impacting their quality and accessibility. Budgeting has been shown to affect the quality of green spaces in general, such as in a report concerning the situation around park management in the UK (Neal, 2016). Another factor is the choice to keep the management of green spaces in-house or contracting out (Lindholst et al. 2020). A comprehensive understanding of school ground vegetation thus requires a multi-faceted approach, including the policy-driven factors that shape these environments.

In addition to governance factors, climatic factors affect school ground vegetation as well. For example, the successful establishment of vegetation is largely contingent on temperature (Kozlowski, 1962). Extended periods of favourable temperatures for growth result in increased biomass production, allowing for greater opportunities to recuperate from wear and tear, an often-appearing hardship on school grounds (Jansson et al. 2014). Temperature has also been shown to affect physical activity on school grounds (Pagels et al. 2014), and seasonal variance of school ground vegetation (fall foliage colour, a mix of evergreens *and* deciduous species, etc.) may have restorative effects (Paddle et al. 2016). Extended growing seasons also imply that children have prolonged access to deciduous vegetation in its leafy state. This may influence how children engage with the vegetation and the effects it may have on them. While some studies have shown that research, in general, is predominantly carried out and published by the Global North (Collyer, 2016, Albanna et al. 2021), it remains unclear if this holds for studies on schoolyard vegetation, specifically because of the multitude of possible geographical variations affecting school ground vegetation. Despite the presence of schools worldwide, research on them might not necessarily be uniformly spread.

This study aims to investigate patterns of research concerning school ground vegetation and identify possible research gaps, with a specific focus on exploring how vegetation and its spatial and temporal qualities are portrayed. For this reason, a mapping review was deemed suitable.

This mapping review explores the following questions: I. What are the characteristics of the research concerning the topic of school ground vegetation? II. How are vegetation and its spatial and temporal qualities reported and described in research concerning school ground vegetation?

2. Methods

A mapping review consists of a broad screening of the scientific literature with a specific question in mind and an analysis of the extent of the research itself, such as addressed topics, methods used, the geographical context in which the research is conducted, etc. (Kitchenham et al. 2010, Booth et al. 2016, Cooper, 2016). As is proper for a mapping review, this study does not examine and synthesise the results of the reviewed studies (Petersen et al. 2008, Kitchenham et al. 2010). In essence, it emphasises the when, where and how of the research, rather than the specific findings themselves. In a mapping review, those methods typical of other systematic reviews for searching and data extraction are used (Kitchenham et al. 2010). To ensure clarity, validity and auditability in this process (Booth et al. 2016), this mapping review was made with a clear systematic approach. A PRISMA review protocol was developed at the start of the process and a PRISMA flow diagram was used to record the filtering of the literature.

2.1. Search scope

The literature included in this study was limited to scientific publications in English up to and including the year 2022, excluding grey

literature. The scope was limited to publications in English because of the language spoken by the authors as well as time and economic constraints considering translation.

Searches were made in two scientific databases and separately in one journal: Web of Science, Scopus and the journal *Children, Youth and Environments* on JSTOR. JSTOR only has issues from *Children, Youth and Environments* up until 2020, and therefore each issue between 2020 and 2022 was manually screened for relevant articles. The two databases were included because of their separate focus and the fact that the subjects concerning vegetation on school grounds can differ widely. The journal *Children, Youth and Environments* publishes much literature concerning vegetation and school grounds but is not included in either Web of Science or Scopus and thus had to be searched separately.

The search strings used were made as alike as possible but had to be adapted to each database. The search strings were built around three aspects. The first two described the place, a place for childcare or an educational facility and specifically its outdoor environment. The third considered the vegetation aspect (full search strings can be found in the Appendix). The process of building the search strings was made in dialogue with a university librarian with special knowledge of methods for systematic literature searches. This has been highlighted as an important factor for high-quality literature searches and reporting (Cooper et al. 2018).

2.2. Search and screening of articles

The first search was made in April 2021, and a complementary search was made in January 2023 to find articles published in 2022. The literature from these searches was screened for duplicates and irrelevant document formats (e.g., Front matter), which were then removed. This resulted in a bulk of literature consisting of 13 403 papers.

In the next stage, the web-based software Rayyan (Mourad et al. 2016) was used to screen for inclusion. All papers were screened separately by reading the title and, if deemed necessary, also the abstract. If there were any doubts, the article was read more thoroughly. The inclusion criteria for the literature reviewed in this study were chosen after discussions among the authors of this study to ensure that the most relevant articles were included. In this stage, also articles of other languages than English were filtered out.

Research concerning schools and vegetation can be made on different spatial levels. Some studies have looked at greenness across whole school districts (Wu and Jackson, 2017) and others have investigated the effects of vegetation surrounding schools (Srugo et al. 2019) or the areas within the school borders. This review focuses solely on the literature concerning vegetation within school borders. This demarcation was made as there are aspects that are special to the vegetation within these borders, such as the increased opportunity for interaction by the children and thereby the possible effects of this interaction (Browning and Rigolon, 2019). In addition, spatial demarcation is reasonable when the purpose is to investigate the level of specificity concerning the description of vegetation. Studies on a district level will naturally more often use broader descriptions (as in Wu and Jackson, 2017) than studies on the school ground level (as in Muvengwi et al. 2019). This limitation filtered out studies that examined, for example, green roofs, which are not accessible to children, and vegetation surrounding schools or within a school district.

Lastly, the age limit for students attending school was set at 20 years old, allowing for an analysis of the spread of research between age groups. No lower age limit was set, which resulted in the inclusion of preschools. No quality assessment of the literature was made since all research made on school ground vegetation was of interest for this review.

2.3. Data extraction and analysis

After screening the literature, 133 articles remained. In the next stage, the full articles were read, and the analysis categories were developed according to the mapping review process (Fig. 1). The process of developing the analysis categories was made through discussions within the author team with the aim of answering the research questions of this study. After the analysis categories were finalised, the main author continued answering them for each article. As the coding was done by only one of the authors, it was re-evaluated several times for each article throughout the process to ensure consistency. In the case of uncertainty, the coding was discussed among the whole author team.

To give insight into the level of activity in the research field and how this has changed over time, the publication growth rate was calculated. This can be used to compare to the overall growth rate of scientific publications. Since the level of activity was seen to increase drastically from 2003 and onwards, the growth rate was calculated with 2003 as the start year. The growth rate was analysed according to Compound Annual Growth Rate (CAGR) $= ((y_n / y_0)\hat{}(1/n) - 1) * 100$, where y_0 represents the value at the start, y_n represents the value at the end of the period, n represents the number of years.

The themes were developed by manually grouping the articles based on the main research purposes of the studies. This inductive method ensured that the resulting themes accurately represented the underlying population. This approach was crucial because it would have been insensitive to the content of the article to apply a predetermined list of categories. The process involved active discussions among the group of authors to ensure the themes were thoroughly developed.

A detailed description of the themes is shown in Tables 1 and 2. After the themes had been formulated, both the main theme and all present themes in the articles were recorded by the main author. To ensure consistency, the articles were analysed multiple times and when any doubt arise this was discussed among the author team.

To determine the association between the themes, the phi coefficient was calculated for each pair of themes. This calculation was based on the co-occurrence of all themes in the articles, thus the main themes and all other themes present. The phi coefficient is a measure of association between two binary values. It is calculated by dividing the number of articles where both themes appeared by the square root of the product of the number of articles where each individual theme appeared. Further, the main themes of the articles were analysed in connection to the categories Description of vegetation and Age of the children studied.

3. Results

Out of the 13,402 unique articles identified through database search, 214 remained after the first screening. After full-text articles were assessed, 133 articles were deemed appropriate for further analysis and thus included in the review.

3.1. Publication year & geographical area

As a whole, research activity on the subject matter has increased during recent decades (Fig. 2). The trend observed since 2003 reveals a CAGR in publications of 13.5 %. On a geographical level, studies that take place in Europe and North America dominate, encompassing 69 % of the total body of literature (36.8 % from Europe and 32.3 % from North America). In North America the studies originate from two different countries while in Europe they origin from 17 different ones. Including the literature from Australia and New Zealand (at 9.7 %) in this group brings the total to 78.9 %. Still, literature on school ground vegetation was found in large parts of the world (Fig. 3). One study did not provide information on the geographical area of the study and was thus disregarded in this analysis.

3.2. Themes

In total, 14 themes were identified within the data corpus, with their prevalence varying significantly from “eco-literacy” being the main

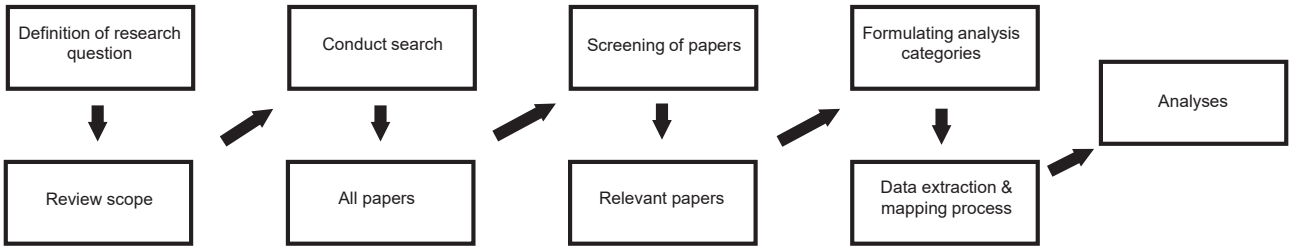

Fig. 1. The mapping review process adapted from Petersen et al. (2008).

Table 1
Analysis categories and short explanation.

Analysis Categories	Explanation
Publication Year	Year of publication
Geographical Area of Focus	The area/continent where the research was conducted
Theme	Aim/purpose of the research
Age range	The age of the children attending the school/ schools under investigation
Description of Vegetation, Type	Level of specificity when describing the vegetation
Description of Vegetation, Size/Shape	Specification of the spatial qualities of the vegetation (Y/N)
Existing or New Vegetation	Investigation of existing or newly planted vegetation
Vegetation Development, Time Aspect	Inclusion of a time perspective, development of the vegetation (Y/N)

Table 2
Detailed description of themes.

Theme	Description
Eco-literacy	Enhancing the relationship between children and the environment/nature through environmental and natural knowledge.
Microclimate	Studies researching atmospheric conditions on school grounds, including temperature and wind patterns.
Children's Perspectives	Concentrates on the diverse viewpoints of school children.
Education and Cognitive Effects	Educational activities' effects, covering attention span and knowledge acquisition.
Gardening	Cultivating vegetables, fruits, and similar produce with school children's participation, often consumed in school or the community.
Physical Activity	School children's physical activity, often using tools like pedometers.
Perspectives of those other than children	Thoughts and experiences of individuals other than school children, like parents or school personnel.
Play	School children's play using methods such as behavioural mapping.
Socio-economic Factors	The socio-economic context of the schools under examination.
Physical Health	Aspects of health such as nutrition, exposure to harmful substances, and toxic plants within school grounds.
Spatial Layout	Extensive focus on the spatial layout of the school grounds, beyond just plans or descriptions.
Mental Health	The mental health of school children, investigating aspects like well-being and restoration.
Biodiversity	Species diversity within the school grounds.
Social Relationships	Interpersonal dynamics among school children.

theme in 20 articles to "social relationships" in just one article. Table 3 shows the number of articles identified within each main theme.

The correlation table (Fig. 4) presents the correlation between the different themes represented as the phi coefficient. This includes all themes present in the articles, and thus not only the main themes. The association between "physical health" and "gardening"; "perspectives of those other than children" and "children's perspectives"; "physical activity" and "spatial layout"; "education and cognitive effects" and "eco-literacy" as well as "microclimate" and "spatial layout" are strongest, with a phi coefficient above 0.3. The theme with the highest number of relatively strong interactions is "gardening" with four interactions above 0.25. There are also several themes that do not interact at all, displayed as a phi coefficient of 0. The three themes "microclimate", "socio-economic factors" and "physical health" had the lowest levels of interaction with other themes, showing no interaction with six other themes. The themes "play" and "social relationships" follow, displaying no interaction with five themes, respectively.

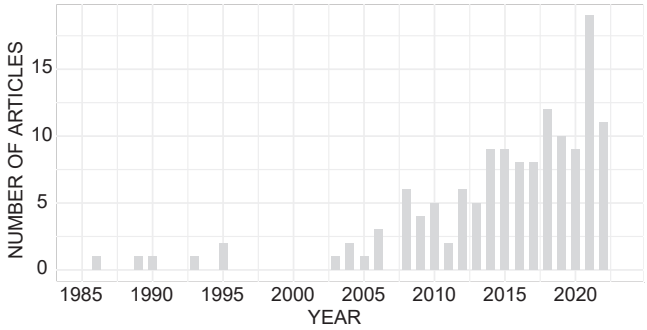

Fig. 2. The number of annual publications on the subject of school ground vegetation.

3.3. Age of children

The overall mean age of the children using the school grounds in the articles is approximately 9 years (9.02) with a median of 9. As shown in Fig. 5, the research is spread across the whole age span of 0–20 years, with less research made on the low and high ages. Seven of the studies did not specify the age of the children and are therefore not included in this analysis.

Relating the main themes of the articles to age ranges shows that the majority of the themes centre on the average age of 9 years (Fig. 6). However, research conducted within the themes of "spatial layout" and "biodiversity" focuses on children with an average age above 11 years (Fig. 6). Conversely, research within the themes of "social relationships", "play", "perspectives of those other than children", and "physical health" pertains to children with an average age below 8 (Fig. 6).

3.4. Description of vegetation

3.4.1. Type

On a linguistic level, the description of vegetation reveals a non-unified naming convention. For example, several articles (n = 26) gather all vegetation under a catch-all phrase here represented as "nature" (other examples of words used are greening, green area, vegetation, and natural elements), whereas others have used more detailed descriptions ranging from naming specific species (n= 38) to types of vegetation being represented in the research (n = 63), dividing the vegetation into trees, shrubs, grass, etc. A few forewent the catch-all

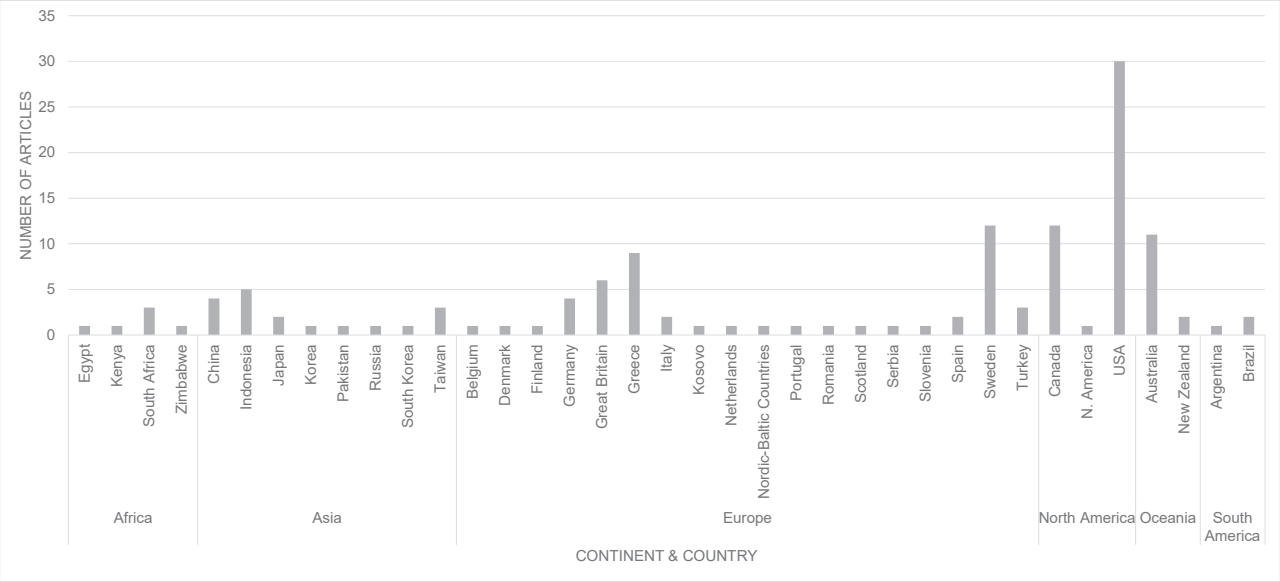

Fig. 3. Geographical location of the studies.

Table 3
All main themes present in the data number of articles are sorted as each main theme.

Main theme	Number of articles
Eco-literacy	20
Microclimate	16
Children's perspectives	14
Gardening	13
Education and cognitive effects	13
Physical activity	12
Perspectives of those other than children	8
Physical health	7
Socio-economic factors	7
Play	7
Mental health	6
Spatial layout	6
Biodiversity	3
Social relationships	1
Total	**133**

phrase and specifications, opting instead to describe vegetation in a quantitative measure as coverage (n = 6).

After examining this in the context of the main themes, some patterns were found (Fig. 7). Certain themes, namely "eco-literacy", "microclimate", and "gardening", are more represented within the group of articles that are species specific as these themes make out nearly 60 % of this group. In the case of "gardening", this species specificity pertains to the explicit mentioning of the cultivated produce, such as vegetables or other crops. Within the "eco-literacy" theme, specificity often relates to the level of knowledge concerning vegetation among children. The "microclimate" theme stands out as the only one incorporating species to explore their specific performance on the school grounds.

Within the group of articles that use catch-all phrases such as "nature", the themes "education and cognitive effects" and "children's perspectives" are common. The main theme "play" is the only one where all studies use the same degree of specificity, vegetation types, to describe the school ground vegetation.

3.4.2. *Size and/or shape of vegetation*

Almost 36.6 % of the studies did not specify the size or shape of the school ground vegetation in any way, while for ~3 % of the studies, this analysis question was not applicable. For 61.2 % that did include descriptions to a varying degree, some included pictures of the vegetated areas in question, some specified areas in square meters or the percentage of total school ground area, while others included plans where it was possible to visually interpret the size and/or shape of the vegetated areas. The level of specificity varied greatly and no clear pattern could be seen when analysing this in connection to the main themes. However, "mental health" is the only main theme where all articles specify size and/or shape to some degree.

3.4.3. *Vegetation development & existing or new vegetation*

A large majority (90.2 %) of the studies lack a time perspective as they do not investigate the development of the vegetation or its function and use to any extent. Also, there is a tendency to examine already established vegetation rather than study proposed designs or newly planted vegetation. 75.1 % of the literature focuses on existing vegetation, around 7.5 % includes both existing vegetation and a design proposal, and approximately 16.5 % specifically investigates newly planted vegetation.

4. Discussion

The results from this systematic mapping review reveals many disparities within the scientific literature on school ground vegetation. There is a wide variety of research themes, which shows a high degree of variation in the driving forces behind school ground vegetation research. There is also variation in the way in which different articles include vegetation in their research and the depth to which they consider it.

The 13.5 % growth rate of publications on school ground vegetation from 2003 and onwards surpasses the estimated average annual growth of scientific publications (5.1 %) when calculated from 1952 to today (Bornmann et al. 2021). It may be unlikely that this upward trajectory will be sustained indefinitely, following the argument by Bornmann et al. (2021) that since human resources and capital are limited, the growth of scientific research must also be limited. However, this recent growth is still notable and shows a high interest in this specific subject. The underlying cause that led to this growth is probably a combination of multiple influences. It can be viewed as a case of bridging the gap with more established research subjects. It may also be within reason to connect this to the interest in practice. With a multitude of school ground greening projects of varying scale across the globe and the research on them (Dyment and Reid, 2005, Sterling, 2005, Giezen and Pellerey, 2021), the interest in this topic seems to exist not only within

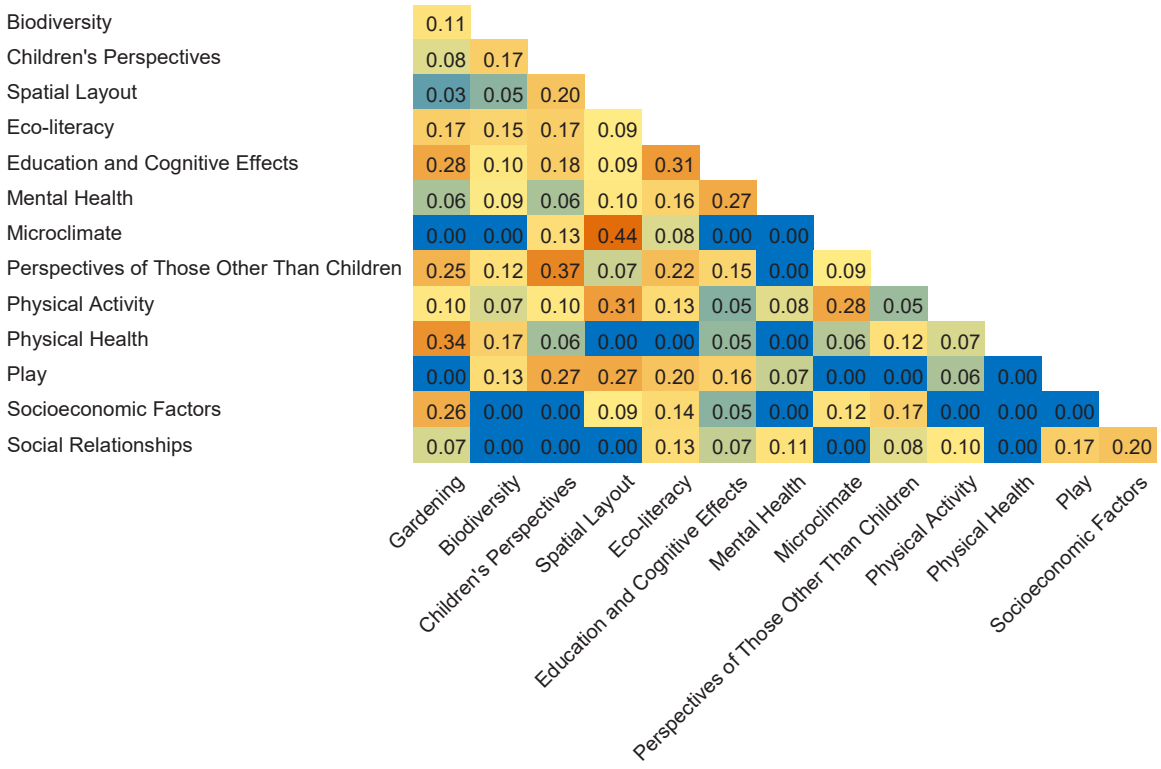

Fig. 4. Correlation table showing the level of association between themes. Red shows a relatively high correlation and blue shows a relatively low correlation between themes (self-correlation not included).

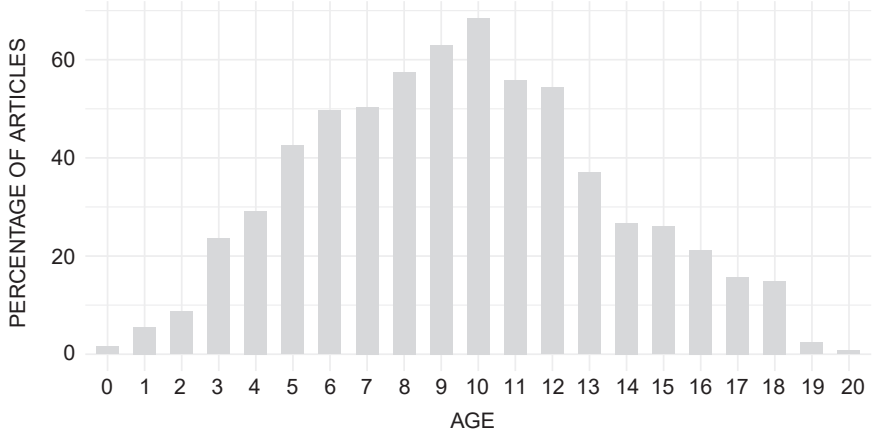

Fig. 5. Percentage of articles that includes the specific ages.

academia as results from this study show, but probably also more broadly. 2007 marks the year when the urban population surpassed the rural one globally (Ritchie and Roser, 2018). With this urbanisation, it is understandable that school grounds are getting more attention as more children are now growing up in cities and urban areas, meaning school grounds are where they spend a majority of their total outdoor time (Wen et al. 2009).

On a geographical level, the dominance of Europe (17 countries), North America (USA and Canada), Australia and New Zealand, comprising 78.9 % of the literature corpus. The studies conducted in North America predominantly emanate from the United States, whereas those originating from Europe encompass a representation of 17 countries. This is important to highlight. The impact that school ground vegetation has on children has been shown to depend on the design and management of school grounds (Malone and Tranter, 2003), processes themselves heavily influenced by prevailing policy frameworks and governance structures (Randrup et al. 2020). Given that these structures may differ between countries, it follows that the condition of school ground vegetation may also exhibit variations on an international scale.

This study only looked at English literature and any possible research published in other languages is thus not included. However, the wide geographical spread of the articles in this review indicates that it has captured at least a part of the discourse in each of the countries in question. And moreover, it is especially interesting to investigate literature in English as this can say something about the production and spreading of knowledge worldwide. In line with the scientific society in general (Collyer, 2016, Albanna et al. 2021), the scientific publishing of school ground vegetation in English predominantly occurs within the context of the Global North. As a result of not being represented in the scientific literature in English, the Global South risks being excluded

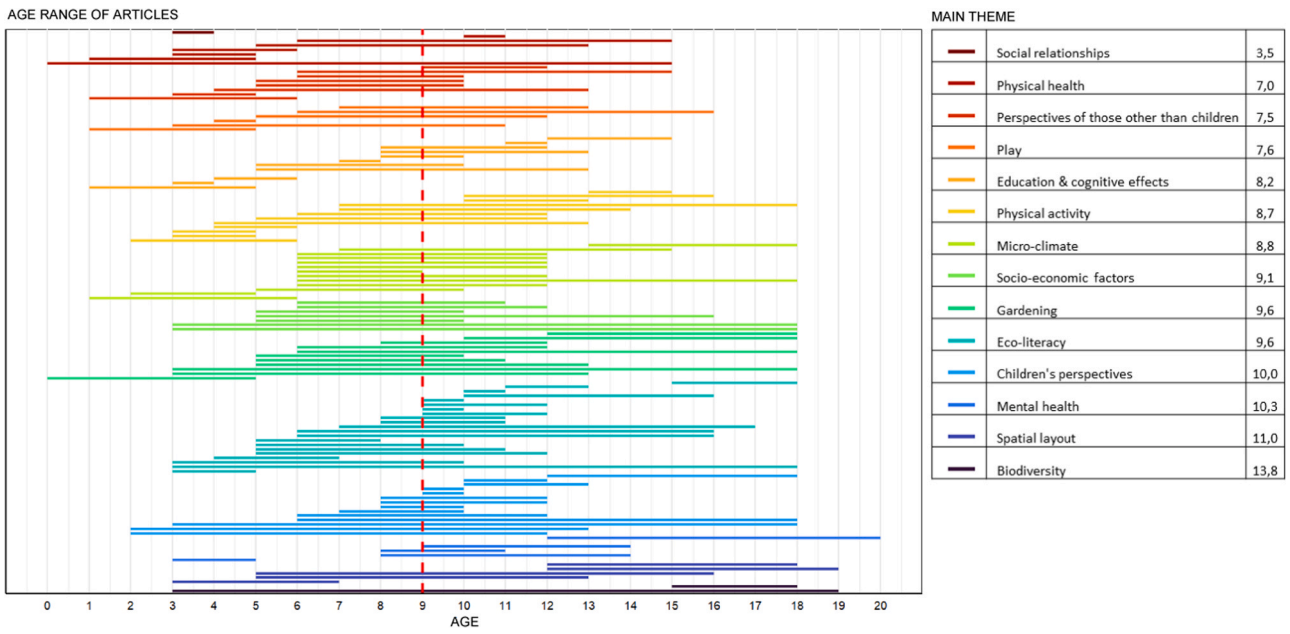

Fig. 6. Age ranges of all articles grouped by main theme. The Red dashed line shows the overall mean. The table shows the mean age for all themes.

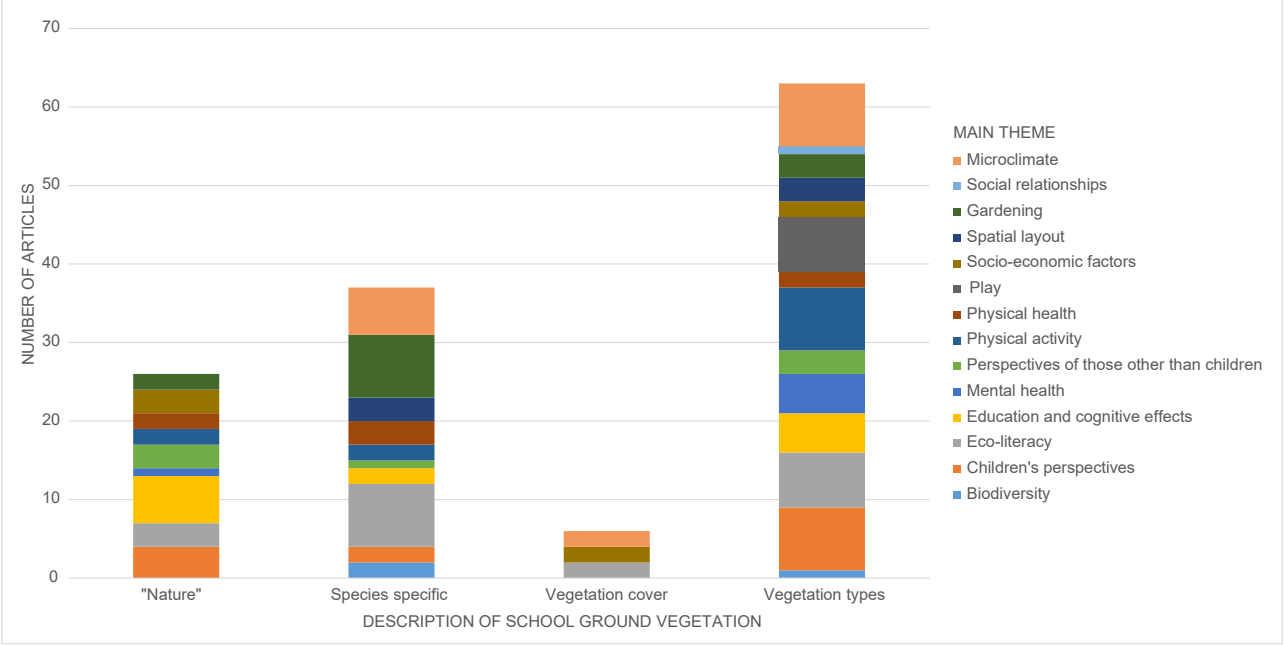

Fig. 7. Showing main themes of the articles and level of vegetation description specificity.

from the production of scientific knowledge and its influence (Collyer, 2016). This may lead to a limited understanding of the needs, impacts and uses of school ground vegetation in these areas. Furthermore, with urbanisation occurring at a faster rate in the Global South than in the Global North (UNDESA, 2018), it is crucial to ensure that school ground vegetation in these regions is not neglected. This importance is only heightened by the fact that cities in the Global South are more vulnerable to the consequences of climate change (Pörtner et al. 2022).

Also, since most research on school ground vegetation relates to the particular climatic and socio-economic contexts of the different countries predominantly within the Global North, results connected to vegetation performance and the effects of vegetation and environment on children should be interpreted with this in mind. The characteristics and appearance of vegetation vary considerably across regions of the world, and caution should be exercised when drawing parallels between studies in distinctly different climates.

There is a low level of uniformity when it comes to the level of specificity when describing vegetation in the studies on school ground vegetation. As this inconsistency also can be found within the main themes in this study, it indicates discrepancies among studies with the same focus. The main theme “play” is the only one where all studies use the same degree of specificity, using vegetation types to describe the content of vegetation on the school grounds. All in all, this implies that there are different dispositions, from being concerned (or unconcerned) with the particular species or type of vegetation to those more concerned with the amount of vegetation. It is clear that a majority of the research includes at least some degree of specificity regarding the vegetation being studied. But issues may arise when wanting to connect results

from different studies or acquire detailed knowledge on school ground vegetation. Vegetation can be highly variable, and general descriptions such as “nature” risk over-simplifying these structures. The results of the studies leaning on general descriptions can be hard to interpret as it is often impossible to know exactly what “nature” consists of in each particular study. This can also be said for the description of vegetation types. Even if this is more detailed than words such as “nature”, it should be noted that vegetation within a vegetation type can vary vastly.

The importance of investigating the effects of school ground vegetation in high detail is also because the performance and thereby benefits often vary greatly between different species (Sjöman et al. 2023). One example of how vegetation provides benefits is through providing shelter from wind and sun radiation. Trees affect the microclimate partly by their canopy cover (Dobbs et al. 2011) and structure (Nowak et al. 2013). Indeed, the literature included in this review shows that the canopy and structure of different types (El-Bardisy et al. 2016) and species (Antoniadis et al. 2016) of trees have different effects on the microclimate of school grounds. Moreover, varied sizes, ages, and species of vegetation offer diverse benefits when it comes to its effects on children, ranging from impacts on biodiversity to its possibility of facilitating children’s play (Laaksoharju and Rappe, 2017) and effects on academic performance (Sivarajah et al. 2018). In the example of the theme “play”, where all studies specified vegetation types, linking their findings may remain challenging due to the fact that two examples of the same vegetation type may still be immensely different from each other.

Additionally, species diversity is connected to the resilience of the vegetational community towards pests, diseases and changes in the environment (Roebuck et al. 2022, Raupp et al. 2006). This makes diversity on school grounds important both for the resilience of the specific school ground but also for the larger area of which the school is a part of. Given the high variation among vegetation as a whole, it is crucial to investigate at a more detailed level than currently is being done. This approach not only aids in comprehending the studies and their outcomes but also to provide a deeper understanding of the effects and contribution of school ground vegetation.

The inclination to generalise and simplify can also be shown in the tendency to study vegetation at a single point in time, as over 90 % did not study the development of vegetation to any degree. This risks oversimplifying the dynamic nature of vegetation and in prolongation overlook the importance of long-term management of the vegetation. As Malone and Tranter (2003) argue, the type of approach towards management on school grounds may have a great effect on how children interact and use the vegetation. This is also true outside of the school ground context where children’s use of green structures has been seen to change as the vegetation develops (Gunnarsson and Gustavsson, 1989). At the same time there is a tendency to study already established vegetation. There are many greening initiatives around the world but not a lot of research being made on such newly planted vegetation. To study vegetation from the very implementation of it gives an opportunity to deepen the understanding of it and the effects it has on people and the surroundings.

The same simplification tendency is represented by the fact that more than a third (36.6 %) of the studies did not specify the size and/or shape of the vegetation to any degree. This is found within all main themes except for the main theme “mental health” in which all studies showed some level of specificity. In certain studies, the size and shape may be of lesser importance, for example, when the sole aim is to conduct a species composition survey. However, for many of the themes present among the literature on school ground vegetation, the size and/or shape of the vegetation may matter much for the functions it can provide, as indicated by several studies (for microclimate in Zhang et al. (2017), for play in Sylvia (2010), for education and cognitive effect in Sivarajah et al. (2018), for physical activity in Puhakka et al. (2019), etc.). To investigate this relationship more, it is necessary to know the specifics of the research, including the spatial qualities of the vegetation. Otherwise, it might be difficult to fully understand the results and conclusions of the research. Studying vegetation dynamics outside of the school ground context has provided a deeper view on the processes affecting vegetation which in its turn may inform management schemes going ahead (Li et al. 2020). The same would be possible for school ground vegetation if the spatiotemporal dynamics would be considered to a greater extent.

It may be understandable that there is a lack of interdisciplinary research within the field when considering the linguistic disparity within this topic. This is further evidenced by the correlation analysis of main themes, many of which completely lack association (displayed as 0 in the correlation table, Fig. 4). There is a high number of themes present within this research subject and therefore some lack of association between themes can be expected. These gaps can represent the need for future research. As global temperatures continue to rise due to climate change (Pörtner et al. 2022), exploring the microclimate of school grounds in relation to "education and cognitive effects" and "mental health" can provide valuable insights into the impact of a warmer learning environment on children’s mental well-being and their ability to engage effectively in learning activities. In the same sense, the influence of microclimate connected to rising temperatures on play patterns and how they may vary with different types of school ground vegetation also remains an interesting and largely unexplored area of study. Interestingly, the themes “mental health” and “physical health” show no overlap despite their interconnectedness (Ohrnberger et al. 2017). By studying both of these in connection to school ground vegetation, a clearer and more comprehensive picture of the effect of vegetation on children’s health could be found. Moreover, when it comes to the multifunctionality of school grounds, the themes “biodiversity” and “play” display two functions of school grounds which are generally not researched together, thus presenting an interesting possibility for future research.

The difference in occurrence between the themes “physical health” and “physical activity” is interesting to note. Twelve studies had a main focus on “physical activity”, whereas only seven studies had a main focus on the broader theme “physical health”. The studies within the theme “physical health” consider subjects as toxic and injurious plants, ingestion of hazardous substances, effects on skin microbiota, and promoting the consumption of more fruit and vegetables. This is different from the studies within the theme “physical activity”, evidently all focused on physical activity. When it comes to aspects of health for children, there is a relatively high focus on studying physical activity in connection to school ground vegetation, while diversifying the focus within physical health further might prove beneficial to explore.

The ages of the children in the studies are spread from 0 to 20 years with a mean of 9.02. When looking at age ranges for the articles of each main theme, there are a few themes that divert from the overall corpus. Within the main theme “perspectives of those other than children”, there is a higher focus on the lower ages shown with a mean age of 7.5. This indicates that for these ages it might be thought especially interesting to investigate parents’ and pedagogical staff’s perspectives. A higher average age for the main theme "mental health” than “education and cognitive effects” indicates a greater interest in looking at learning capabilities in lower ages and factors such as restoration in higher ages.

4.1. Limitations to the study

Grey literature was excluded in this mapping review. Even if interesting information can be found concerning school ground vegetation in, for example, fact sheets and government documents, it is of specific value to investigate the characteristics of scientific literature. Furthermore, google scholar was not used for literature searches even if it is a commonly used search engine in academia. Because of drawbacks inherent to its structure and programming it is less suitable for being used in systematic reviews (Boeker et al. 2013). Google scholar may be of good use when searching for specific articles or for grey literature but as of now the drawbacks outweighs the benefits for its use in systematic

reviews focusing on scientific literature.

This review only includes scientific literature in English. It is important to note that this decision on scope may have resulted in the omission of relevant studies in the countries represented in this review, as well as in other areas of the world. In the medical field meta-reviews have shown that only including English literature has no effect on conclusions of the reviews in question (Dobrescu et al. 2021, Morrison et al. 2012). But as this review also investigates the geographical spread of the scientific literature these results might partly be explained by this focus on English literature. Readers should thus be aware of this limitation and its possible consequences.

This study relies on database searches and searches for *Children, Youth and Environments,* and therefore the limitations of these may affect the results. The search strings used were developed to be as inclusive as possible while at the same time limiting the number of irrelevant publications. It is, however, possible that some relevant articles may have been omitted from the conducted searches, possibly attributed to variations in terminology used.

Lastly, it is important to note that caution should be exercised when drawing conclusions based on themes that are supported by only a small number of articles. It can be challenging to make definitive statements from these findings, as there is a possibility that the observed trend is more coincidental than representative of a consistent pattern.

5. Conclusion

This review underscores the high diversity and variability present in the research concerning vegetation on school grounds. The variability in content and language poses challenges in connecting and synthesising research findings across different fields, making it difficult to draw comprehensive conclusions. To mitigate these issues, more focus on describing the content and spatial qualities of school ground vegetation in detail could greatly enhance the clarity with which results are interpreted and connected.

Given the growing interest in this area of research, it can be anticipated that future studies will strive to bridge the gaps between disparate themes and fields, thereby creating a more integrated understanding of the topic. The correlation analysis in this review can prove instrumental in this, displaying research gaps between, for example, the theme “microclimate" and “play”/”biodiversity”/”education and cognitive effects”/”mental health”, “mental health” and “physical health” as well as “socio-economic factors” and “physical activity”/”physical health”. To conduct research around themes that do not yet overlap in the research may be of special interest in the research field of school ground vegetation due to its expected multifunctionality and the value of interdisciplinary approaches in further developing the field.

Lastly, this review also shows that the majority of existing research in English has primarily concentrated on the Global North (Europe, North America, Australia and New Zealand). This presents an opportunity and also a need to explore regions beyond these geographical areas. Expanding the scope of study to other parts of the world can provide valuable insights and contribute to a more comprehensive understanding of the topic. The geographical context should also be taken into consideration when results from different studies are connected because of the possible big differences within climate and socio-economic aspects.

Funding

The research was part of a project funded by Formas (Swedish Research Council for Sustainable Development).

Ethical statement

The research was conducted ethically and in accordance with relevant guidelines and regulations.

Declaration of Competing Interest

No conflicts of interest

Appendix 1

PRISMA 2009 Flow Diagram. *From:* Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097. **For more information, visit** www.prisma-statement.org**.**

Appendix 2

Search strings

For Web of Science, the following search string was used:

((school* OR preschool* OR daycare OR childcare OR *“child-care”* OR kindergarten) AND (ground* OR yard* OR play* OR area* OR environment*) AND (vegetation OR tree* OR bush* OR plant* OR “green area*” OR “green structure*” OR greenness))

For Scopus, the following search string was used:

TITLE-ABS-KEY ((*school** OR *preschool* OR *daycare* OR *childcare* OR “*child-care”* OR *kindergarten*) AND (*ground* OR *yard* OR *play** OR *area* OR *environment*) AND (*vegetation* OR *tree* OR *bush* OR *plant* OR *"green area"* OR *"green structure"* OR *greenness*))

Lemmatisation is automatically included when searching in Scopus so * was only used when a compound word was meant to be included as school*yard* or play*ground.*

Because of the word limit when searching in JSTOR, searching the journal “Children, Youth and Environments” had to be divided into two search strings and shortened. The part including space (ground/yard/environment etc.) was excluded since the focus of the journal itself can be expected to include this aspect already. The search strings used were the following:

(school* OR preschool* OR daycare OR childcare) AND (vegetation OR tree* OR bush* OR plant* OR "green area" OR "green structure" OR greenness)

And:

("child-care" OR kindergarten) AND (vegetation OR tree* OR bush* OR plant* OR "green area" OR "green structure" OR greenness)

Appendix 3

List of included articles

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