Universität Bremen

artec Sustainability Research Center

Michael Flitner, Johannes Herbeck, Sophia Segler, Martina Grimmig (Eds.)

Urban Green Spaces: Assessment and Observation

Biodiverse Cities:
Social-ecological Studies in Bremen-Gröpelingen I

artec Paper Nr. 232/233
July 2024

artec Sustainability Research Center

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July 2024
ISSN 1613-4907

Contents

Foreword

With this edited volume we open a series of contributions on questions around urban greening and biodiversity, with a focus on the City of Bremen and its surroundings, and in particular on the district of Gröpelingen. One reason for this focus stems from an EU-funded Research and Development Project that brings together eight cities and the same number of expert organisations from north-western Europe to "accelerate action for biodiversity in cities in the North Sea area" and promote what has been termed "nature-based solutions" (NBS) in the partner cities and beyond.[1] The city of Bremen is one of the main partners in that project, and the University of Bremen is one of three academic institutions directly involved in it. More specifically, the Bremen University team brings together researchers from the artec Sustainability Research Centre and the Department of Anthropology and Cultural Research (IfEK) with its Gröpelingen Research Workshop (Forschungswerkstadt Gröpelingen).[2]

However, the interest of our research group in urban natures goes clearly beyond this one project. Some of us have been carrying out social-ecological studies and looking into the development of cities as "more than human" assemblages in diverse urban settings and on several continents. Regarding Bremen, members of the group have been and continue to be active in research and teaching activities, including many student projects.

In this first volume of Biodiverse Cities – Social-ecological Studies in Bremen-Gröpelingen we present three studies that have been carried out by students in different roles, under our supervision, either as research assistants in the project mentioned above, or in the course of their academic qualification. Firstly, ecologist Lorena Kalvelage has carried out a field survey of two areas in Bremen-Gröpelingen that were of particular interest for us (and the project). In her vegetation assessment she produces a first baseline assessment of vascular plant species in one very urban square (Bürgermeister-Ehlers-Platz) that is foreseen as a site of intervention in the Interreg project. A second site she surveyed was a much less managed bushy grassland behind the housing complex Wohlers Eichen, a former industrial wasteland and mostly ruderal habitat. On this site, as well, a major intervention is upcoming in the form of a "climate forest park" that shall be built there in the coming year(s). This development is not part of the same project but gives an interesting contrast in its vegetation and shows some of spontaneous (and later planned) regreening in the region. In its Annex, the study provides for the first plant list of the two sites.

The two other papers of the volume relate to the same two sites. In the second paper, ecologist David J. Torne focuses on the area first mentioned above with a different approach. Making use of available maps, raster images and publicly available data from the Bremen Geoportal he analyses the (potential) ecological connectivity of the Lindenhof quarter with a focus on urban trees. He can show among other things how the view on "private" trees in the gardens which he draws from the images gives decisive additional information which is not accessible in the typical publicly available formats. On that basis, he develops a practical proposal for the analysis of urban tree distribution that can be useful for urban planning purposes.

In the third paper, geography student Lena Wende provides us with an observational study regarding the utilization of the ruderal site next to Wohlers Eichen. In her study, she has observed only a very limited use of the area by people just walking through, walking their dogs, only a few of them also using the space for recreation, rest or playing. Despite its limited scope and coverage – which the author acknowledges - the exploratory study

[1] See the Interreg Project Biodiverse Cities, https://www.interregnorthsea.eu/biodiverse-cities
[2] For a short description see https://www.uni-bremen.de/en/artec/forschung/laufende-projekte/biodiverse-cities-interreg-north-sea-program

suggests that there is a lot of room for making this area more attractive for a bigger number of more diverse users and, hopefully, this can also be done without impacting negatively on the biodiversity that we already find in this area, as documented in the first paper.

We hope that these and the following studies will find interest not just in our scientific community and the wider research project, but also among the practitioners involved in the different development schemes, as well as urban nature lovers and other citizens interested in the changing urban natures.

Michael Flitner, Johannes Herbeck, Sophia Segler, Martina Grimmig

Lorena Kalvelage

Urban Flora: Vegetation Assessments in Gröpelingen and Oslebshausen, Bremen

1. Introduction

The reshaping of natural environments is a global phenomenon challenging the coexistence of urban spaces and nature. Studying our environment comprehensively is key to developing more sustainable urban structures and processes. Plants in particular offer a diversity of study options as well as options for ecological, aesthetic and cultural improvements to the benefit of urban dwellers.

Climate change intensifies the need to understand the urban flora to preserve and enhance the quality of life for both vegetation and residents. For this paper, we have investigated vascular plants, which are a rich and diverse botanical group with species ranging from trees to wildflowers and grasses. Not only do these plants play a crucial role in urban ecosystems, they also influence air quality, regulate temperature and more broadly enhance human wellbeing also by their aesthetic value and cultural significance (Grote et al., 2016).

The study aimed to conduct a first baseline analysis of vascular plants species within two areas situated in the north-western parts of Bremen (Germany), namely the districts Lindenhof and Oslebshausen, both part of the borough of Gröpelingen. Through comprehensive field surveys over six months (May through October 2023), a documentation of all found plant species was produced. This is the initial step in characterizing the existing flora and identifying potential measures for conservation, biodiversity enhancement and related awareness rising. With this assessment we seek to provide a foundation for informed decision-making and citizen engagement, hoping to achieve a more sustainable future for the study area.

The following report will present and discuss the methodology and the results of our study and conclude with a proposal for further implications and follow-up research. The field study was carried out by the author (LK) who also wrote the first draft of this report. The design of the study and the results as well as their presentation were discussed and commented on by the members of the Biodiverse Cities team at Bremen University's Sustainability Research Center. The draft version was reviewed and edited by the author (LK) and Michael Flitner. The discussion section with its proposals for management represent the ideas of the author (LK).

2. Methods

2.1 Study area

The city of Bremen with the borough of Gröpelingen is situated in northwestern Germany. Bremen's climate is temperate maritime and often accompanied by strong winds. While the average annual temperature is around 10°C, it is characterized by fairly mild, damp winters, only occasionally below freezing (Ø°C coldest month, January: 2.3°C) and cool summers (Ø°C hottest month, July: 18.1°C). Like in other parts of northwestern Europe, sunshine is rather scarce, especially during winter months (ClimateData.org). Shaped by these environmental conditions, the potential natural vegetation would be comprised of mostly deciduous forests, with only waterbodies, dunes, bogs and stone environments forming an exception (Bundesamt für Naturschutz, 2010). However, anthropogenic influence has strongly shaped current land use patterns and changed the vegetation dramatically by draining bogs, compacting soils, channeling and dyking the Weser river, extensive building, industrial estates, and so on.

2.2 Study sites

Figure 1 shows a map of Bremen with our study sites. These are presented by the red drop-shaped dots. Furthermore, the different background colors indicate the habitat type as classified by Bremen's geoinformation agency (see caption below; for a more detailed explanation go to Landesamt Geoinformation Bremen, https://www.geo.bremen.de).

Figure 1: Habitat type map of Bremen, showing parts to the North-West of the city center. Red drops mark the two study sites; the background colors red and gray: residential and industrial sites; brown: wooden areas/perennials; beige-green, yellow-green: allot-ment gardens and green spaces; light-green: species poor, intensive wet grassland; neon-green: nutrient-rich, species poor, wet extensive grassland (simplified).

While both areas are surrounded by residential buildings and industrial sites, they are quite diverse in several respects. Bürgermeister-Ehlers-Platz (BME) is characterised by a high degree of soil compaction, an urban square covered by cobblestones, leading to reduced water absorption, surrounded by a single line of trees and a car parking lot with a small grassland area.

Figure 2: Picture of the first study site Bürgermeister-Ehlers-Platz (BME)

The area size amounts to approx. 3150m², with the grassy area covering approx. 700m² and trees sheltering an area of about 1450m². About 1000m² are uncovered cobblestone. Figure 2 shows a picture of Bürgermeister-Ehlers-Platz in June. This study site experiences frequent management by mowing (the outer parts and margins) as well as periodical intensive use by weekly markets and occasional fairs.
About 3km northwest of BME we find a bushy grassland, which was our second study site, the greenspace next to the housing complex Wohlers Eichen (GWE). This is a largely ruderal habitat and former industrial wasteland that has developed into an urban "greenspace" (Taylor, Hochuli, 2017) and is earmarked for development into a park in the near future. While being situated between a dense residential area and a busy industrial park, only footpaths cross this area bordered to the south by a narrow strip of trees. With around 9600m² it is almost three times as big and shows few signs of soil compaction through current use. Of these 9600m² roughly 2300m² are shaded by trees and bushes, leaving about 7300m² of open, mostly unmanaged vegetation. Figure 3 presents this study site.

Figure 3: Picture of the second study site greenspace Wohlers Eichen (GWE)

2.3 Vegetation assessment methodology

The vegetation assessment was conducted over a period of six months from May through October, 2023. Each of the two sites was visited four times through the six months period, to account for early and late blooming species and observe the full vegetation cycle, facilitating correct species identification. By moving systematically through the sites, full coverage of all plant species in the area was intended. This was accomplished by concentrating on approx. two square meters at a time and thus moving around the field. For guidance, a measuring stick was utilized. Species identification took place in situ either utilizing identification apps (Pl@ntNet, iNaturalist) followed by verification via literature or classic identification using only the plant identification guide (Jäger, 2017). Identification that turned out to be difficult in the field was carried out at home after the unidentified specimen were extracted and transferred into a bag for conservation and transport. Primary objects of identification were the herbaceous plants, but a broader identification of shrubs and trees was carried out additionally at a later stage, too. All identified plant species were assembled in a table (see annex). Due to the repeated management by mowing at BME, it was not possible to identify all grasses to the species level, which is why a portion was identified to genus level only. Since the task of tree identification was added later to our project, most of them are identified just to genus level, too. Data analysis and visualization was carried out by utilizing RStudio (RStudio Team 2020) and Excel (Windows, 2016).

3. Results

Altogether, plant identification resulted in 108 different species belonging to 32 plant families. Figure 4 shows the distribution of plant families found on the two study sites, respectively. Plants from 15 families are present at GWE only, while BME harbors 4 families exclusively. 14 families were found on both sites.

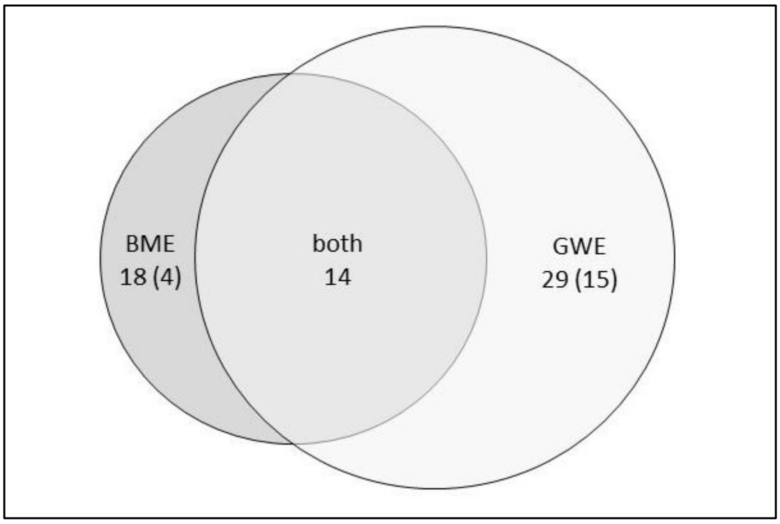

Figure 4: Number of plant families on the respective study sites. Dark gray shows the number of plant families at BME, light gray for GWE; the overlap shows the number of families occuring in both locations. Number in brackets are for plant families found exclusively on the respective site.

Figure 5 presents the same findings based on the plant species identified. While GWE accommodates 56 species exclusively (light gray), BME had 34 species we couldn't find at GWE (dark gray). 18 species were found in both areas (overlapping section).

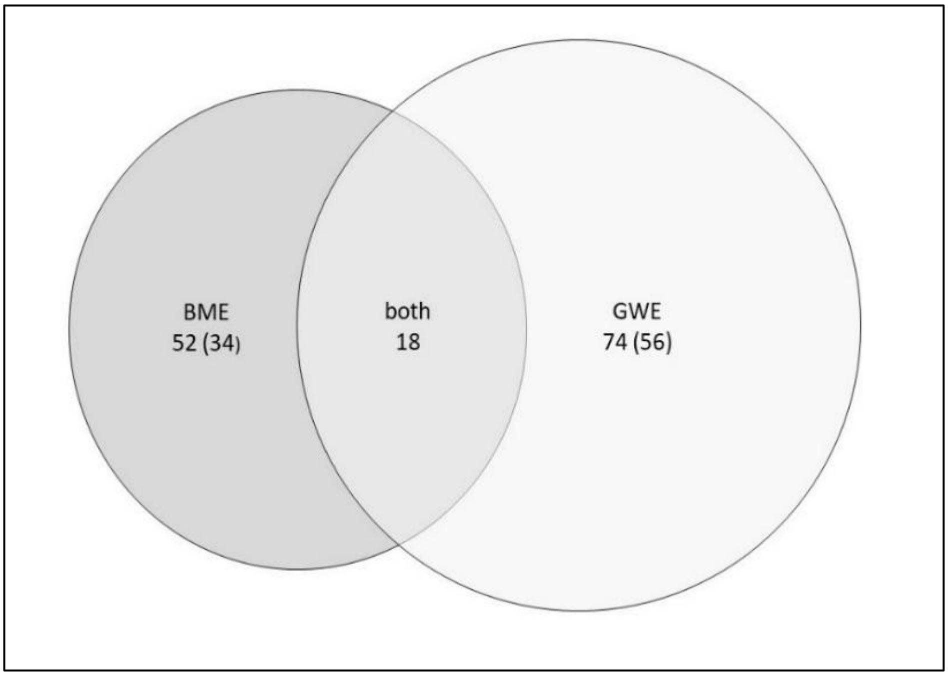

Figure 5: Number of species found at BME (dark gray), and GWE (light gray) and number of species found in both areas (overlapping section). Numbers in brackets are for plant species found exclusively on the respective site.

3.1 Bürgermeister-Ehlers-Platz

Plant identification resulted in 52 species of 18 different plant families for BME. Of these 52 species only 2 are genera of trees. Figure 6 depicts the number of species identified for different plant families found at the site. The most prominent family at BME were Asteraceae with 13 different species, followed by Poaceae with 8 species. The family with the third most species were Fabaceae with 4 different species as shown in Figure 6.

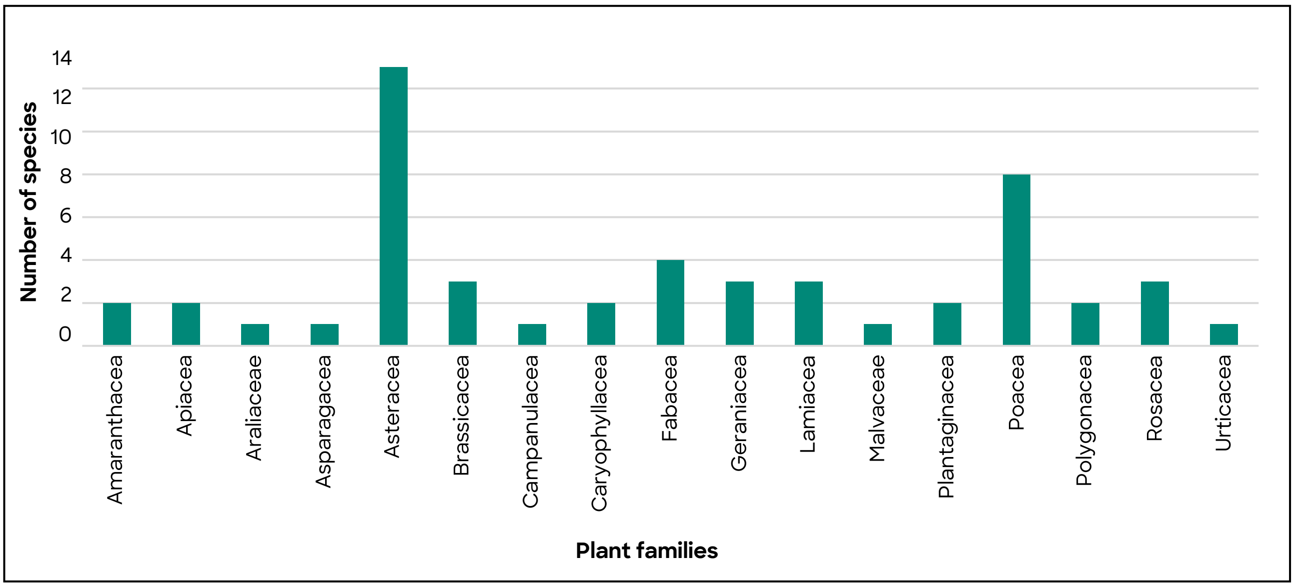

Figure 6: Diagram showing the number of species (y) and the plant families (x) found at BME.

3.2 Greenspace Wohlers Eichen

The second study site showed 74 species of 28 different plant families. Among them, we found 8 tree genera. In contrast to BME, this site is dominated by species of Poaceae with 13 species, followed by Fabaceae, where we found 10 species. Rosaceae and Asteraceae follow, with 9 and 7 species, respectively. Figure 7 shows all found plant families and their individual species count; several families were represented by only 1 species and a few by 2-4 different species.

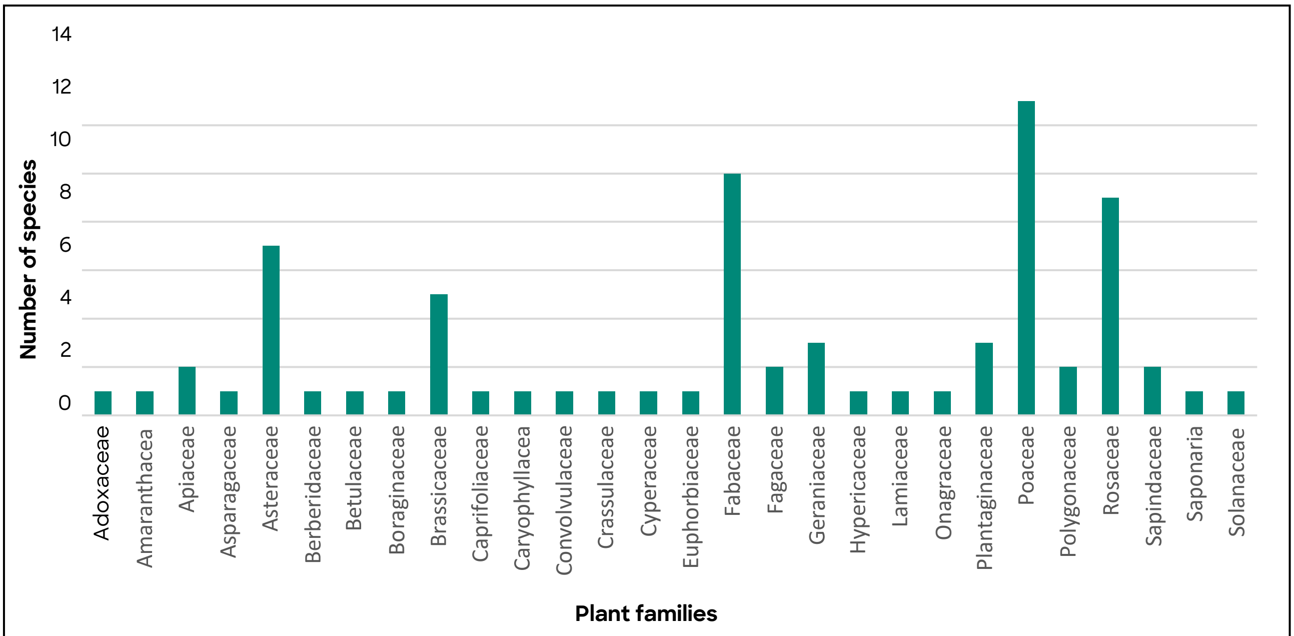

Figure 7: Diagram presenting the number of species (y) and their plant families (x) found at GWE.

4. Discussion and management options

Taking the diversity and divergence of site parameters into account, we refrained from a detailed comparison of the two sites in statistical terms, but rather took away information from both situations. Nonetheless, we will discuss the collected information and potential for improvement and different approaches for follow up research.

BME suffers from a (relatively) high degree of soil compaction and sealing caused by cobblestones (partially sealing) and usage (e.g. markets and different types of social gatherings). The scarce space in between trees and stones can make it hard for the vegetation to reach potential and reproduction, which is why plant growth is limited. Apart from this, sealed soil generally contributes to a higher temperature, urban heat islands, that not only reflect and absorb heat but also store it and emit it slowly. As a result, cities and their urban areas stay heated for longer periods, rain evaporates rapidly and the local microclimate is affected. Furthermore, compacted and sealed soil obstructs rainwater seeping into the soil, thus limiting gas and energy exchange as well as water availability for plants and groundwater restocking (Scalenghe, Marsan 2008). Improving water recycling is of growing importance, however, because groundwater is receding and dry periods are getting longer. By reducing the amount of sealed surface, multiple problems could be addressed. Using a combination of stony grass, lattice stone/hollow paving stones or wooden chips, rainwater could much better infiltrate the soil, plants could access water better and thrive, while still keeping successive growth at pace and maintaining the area accessible for vehicles.

In addition to aforementioned points, the very frequent management through mowing has likely reduced plant species diversity, leading to few competitive species taking over. Cutting vegetation frequently inhibits many species from completing their vegetation cycle, thus constraining reproduction. Cullet et al. (2018) found a dramatic increase in plant community diversity with reduced management in urban areas, while Proske et al (2022) found a similar effect on arthropods, leading us to underline the importance of pursuing research on these sites. Future management should therefore ease pressure, other improvements for species diversity could include introducing (mobile) raised flowerbeds that either can be employed as flower strips or community gardens, or both. When introducing new species, location-appropriate seeds should be used, to ensure ecological meaningfulness.

In addition to habitat loss, habitat fragmentation is a major problem for plant as well as insect species. While there are multiple factors and depending on the degree of isolation, species richness is linked tightly to habitat connectivity (MacArthur et al. 1967, Wilson et al. 2015). Hence, using the location of BME and improving its vegetation diversity, it could act as corridor or bridge for surrounding terrains for plant as well as insect species. Not only will this generate a more attractive environment for flora and fauna, but also for residents. Involving them in caring for the crops and plants could reduce the need for external management while simultaneously offering them the benefits of harvest and community building. Awareness raising and environmental education could be facilitated by setting up information boards, explaining planted species, their benefits, usage and why they were planted, as well as informational events. For establishing community gardening, a more intense commitment will be needed to ensure proper care, with regular visits and courses for designated carers etc.

Although management frequency should decrease, it is important to follow up on plant species distribution. Especially invasive species can threaten the survival of native plants, which makes monitoring these plants highly significant. The federal office for nature conservation (Bundesamt für Naturschutz, BfN) published a guide for nature conservation relevant invasive plant species for Germany (Nehring et al. 2013). In this guide, the authors compile different lists of 'black' and 'grey' species, categorized according to the risks and benefit potentials, and coming with specific management needs for the different levels. 'Grey' species, for example, should be

monitored or, where necessary, can managed at a local scale. Species on the 'black' list, in contrast, should always be managed actively as they have a proven record of negative impact on biological diversity and ecosystem functioning (Weber, Gut 2004). Of the identified species on our study sites, a total of four species are considered invasive. These species are Senecio inaequidens (grey list), Mahonia aquifolium (grey list), Lycium barbarum (grey list) and Rosa rugosa (black list). For more details read the BfN guide noted in the references (Nehring et al. 2013).
Most of the above-mentioned proposed measures refer to BME. We judge the situation at GWE differently, due to the difference in usage, sealing and initial situation. Given the minimal soil sealing, measures for soil improvement could aim at decreasing the area inhabited by grasses with the help of location-appropriate seed mixes. This could be achieved through cutting the grass, manipulating and loosening the soil utilizing a garden tiller. Netzwerk Blühende Landschaft (Network of blooming landscapes) pursued an interesting attempt to diversify intensively used land, where they tried to reintroduce lost plant species into a monocultural grassland. Here, they opened the soil in different percentages of opened/untouched soil and sowed a seed mix. With specific management and accompanying research they found a drastic increase in both plant and insect diversity and number in only two years. Details of this study can be explored further at their internet site (https://bluehende-landschaft.de/).
In general, GWE seems an interesting and promising site with vast potential for developing a biodiverse refuge with limited effort. However, four of the discovered invasive plant species were encountered on GWE. Especially the black list species, Rosa rugosa, requires management, while Lycium barbarum, Mahonia aquifolia and Senecio inaequidens make monitoring a necessity.
Follow up research is suggested to gather a fuller picture of potential ecological measures for both sites. In particular, additional information about insects would be of high value, as they are tightly linked to plants for foraging food, nesting material and habitat. Hence, an insect monitoring at the level of families or species of interest could help to get further clues how to improve both sites in terms of biodiversity.
Additionally, soil sample probes could help gather knowledge about factors influencing the thriving of plant species, thus improving prospects with sowing an adjusted seed mix. Plant available phosphate, water availability and amount of nitrate are only a few possible measurements helping to select the correct management as well as fitting plant species. Arranging test quadrants for seed mixes could be an alternative or addition to testing the soil, investigating which sowed plant species are competitive and tolerate the respective sites. Additionally, this would already bring flowering effects, diversify the habitat, and may be attractive for residents and fauna likewise.

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Annex

Species	**Trivial name**	**Family**	**Location**	**Red List comments***	**Atlas of fern and flowering plants of the Weser-Elbe-area***
Sambucus nigra	Elderberry	*Adoxaceae*	2	not threatened, very frequent	nitrogen pointer, fruits used juice, soup or gelee, homeopathic, pharmaceutical
Artiplex patula	Spear saltbush	*Amaranthaceae*	1		poisonous for livestock, pharmaceutical
Chenopodium album	Melde	*Amaranthaceae*	1, 2	not threatened, very frequent, sig. Increase	poisonous for livestock, pharmaceutical
Anthriscus cerefolium	Chevril	*Apiaceae*	1	not threatened, rare	
Chaerophyllum spp.		*Apiaceae*	1		
Daucus carota subsp. Carota	Wild carrot	*Apiaceae*	2	not threatened, very frequent	most important feeding plant for the very rare swallowtail (Papilio machaon)
Visnaga daucoides	Toothpickweed	*Apiaceae*	2	neophyte	
Hedera helix	Common ivy	*Araliaceae*	1	not threatened, very frequent	late blooming → important pollinator plant, homeopathic, pharmaceutical
Asparagus officinalis	Asparagus	*Asparagaceae*	2	not threatened, frequent	feral vegetable plant, homeopathic, pharmaceutical
Muscari spp.	Grape hyacinth	*Asparagaceae*	1	(potentially rare), neophyte	
Artemisia campestris	Fiel wormwood	*Asteraceae*	2	not threatened, frequent	pharmaceutical
Artemisia vulgaris	common mugwort	*Asteraceae*	1, 2	not threatened, frequent	blooming twigs used as seasoning, poisonous for livestock, pharmaceutical
Bellis perennis	Daisy	*Asteraceae*	1	not threatened, very frequent	very long flowering period, edible, medicinal
Cirsium vulgare	Spear thistle	*Asteraceae*	1	not threatened, very fequent	pharmaceutical, high pollen flower, nitrogen pointer
Crepis biennis	Rough hawksbeard	*Asteraceae*	1, 2	not threatened, frequent	
Erigeron canadensis	Canadian horseweed	*Asteraceae*	1, 2	neophyte	pharmaceutical, homeopathic
Erigeron floribundus	Tall fleabane	*Asteraceae*	2		
Galinsoga parviflora	Quickweed	*Asteraceae*	1	not threatened, neophyte	edible, pharmaceutical, homeopathic
Hieracium umbellatum	Canadian hawkweed	*Asteraceae*	2		
Hypochaeris radicata	Catsear	*Asteraceae*	1	not threatened, very frequent,	bee-plant, pharmaceutical
Matricaria discoidea	Wild chamomille	*Asteraceae*	1	neophyte	pharmaceutical

1 = found at BME, 2 = found at GWE, bold typeface indicates problematic invasive species/neophytes.
*Information gathered from: Metzing et al. (2018). **Information gathered from: Cordes et al. (2006).

Species	Trivial name	Family	Location	Red List comments*	Atlas of fern and flowering plants of the Weser-Elbe-area*
Mycelis muralis	Wall lettuce	*Asteraceae*	1	not threatened, very frequent	pharmaceutical, urbanophile
Senecio inaequidens	narrow-leafed ragwort	*Asteraceae*	1	sig. increase	**poisonous, neophyte**
Sonchus asper	Prickly sow-thistle	*Asteraceae*	2	not threatened, very frequent, sig. Increase	
Tanacetum vulgare	Tansy	*Asteraceae*	1	not threatened, very frequent	deworming properties, homeopathic, pharmaceutical
Taraxacum spp.	Dandelion	*Asteraceae*	1		species ID only by specialists
Tragopogon pratensis	Meadow goat's-beard	*Asteraceae*	1	not threatened, very frequent	edible as young plant, pharmaceutical
Mahonia aquifolium	Holly-leaved barberry	*Berberidaceae*	2		**feral garden plant, neophyte**
Corylus avellana	Common hazel	*Betulaceae*	2	not threatened, very frequent	edible fruit, good wood, pharmaceutical
Echium vulgare	Viper's bugloss	*Boraginaceae*	2	not threatened, very frequent	popular wild bee plant, pharmaceutical
Arabis agg.	Rockcress	*Brassicaceae*	1		
Berteroa incana	Hoary berteroa	*Brassicaceae*	2		neophyte
Capsella bursa-pastoris	Shepherd's purse	*Brassicaceae*	1, 2	not threatened, very frequent	edible, pharmaceutical, homeopathic
Sisymbrium altissimum	Tall tumblemustard	*Brassicaceae*	2		neophyte, pharmaceutical
Sisymbrium officinale	Hedge mustard	*Brassicaceae*	1, 2	not threatened, very frequent, sig. increase	pharmaceutical
Campanula trachelium	nettle-leaved bellflower	*Campanulaceae*	1	not threatened, rare	pharmaceutical
Lonicera periclymenum	Honeysuckle	*Caprifoliaceae*	2		homeopathic, pharmaceutical
Silene dioica	Red campion	*Caryophyllaceae*	2	not threatened, frequent	feral garden plant, important butterfly plant
Spergularia rubra	Red sandspurry	*Caryophyllaceae*	1	not threatened, frequent	pharmaceutical
Stellaria media	Chickweed	*Caryophyllaceae*	1	not threatened, very frequent	edible, homeopathic, pharmaceutical
Convolvulus arvensis	Field bindweed	*Convolvulaceae*	2	not threatened, very frequent	chocolaty smell, pharmaceutical, homeopathic
Sedum acre	Mossy stonecrop	*Crassulaceae*	2	not threatened, very frequent	poisonous, pharmaceutical, homeopathic
Carex sp. (arenaria)		*Cyperaceae*	2	not threatened, mod. frequent, high accountability	
Euphorbia esula	Green spurge	*Euphorbiaceae*	2	not threatened, mod. frequent	poisonous spurge, pharmaceutical
Coronilla varia	Cornvetch	*Fabaceae*	2	not threatened, mod. frequent	neophyte, moderately poisonous, pharmaceutical
Lotus corniculatus	Common bird's-foot trefoil	*Fabaceae*	2	not threatened, very frequent	pharmaceutical
Medicago falcata	Sickle alfalfa	*Fabaceae*	2	not threatened, frequent	rare in northern Ger, neophyte

1 = found at BME, 2 = found at GWE, bold typeface indicates problematic invasive species/neophytes.
*Information gathered from: Metzing et al. (2018). **Information gathered from: Cordes et al. (2006).

Species	Trivial name	Family	Location	Red List comments*	Atlas of fern and flowering plants of the Weser-Elbe-area*
Medicago lupulina	Hop clover	*Fabaceae*	1	not threatened, frequent	nutritious feed and pioneer plant
Medicago sativa	Alfalfa	*Fabaceae*	2		
Medicago x varia		*Fabaceae*	2		livestock feeding plant, neophyte, homeopathic, pharmaceutical
Trifolium arvense	Hare's-foot clover	*Fabaceae*	2	not threatened, very frequent	pharmaceutical
Trifolium dubium	Lesser trefoil	*Fabaceae*	1, 2	not threatened, very frequent	livestock feeding plant
Trifolium medium	Zigzag clover	*Fabaceae*	2	not threatened, very frequent	
Trifolium pratense	Red clover	*Fabaceae*	1	not threatened, very frequent	livestock feeding plant, edible
Vicia hirsuta	Hairy vetch	*Fabaceae*	2	not threatened, very frequent	
Vicia spp.	Vetches	*Fabaceae*	2		
Vicia tetrasperma	Smooth vetch	*Fabaceae*	1	not threatened, very frequent	
Fagus sp.	Beech	*Fagaceae*	2		
Quercus sp.	Oak	*Fagaceae*	2		
Erodium cicutarium	Common stork's bill	*Geraniaceae*	2	not threatened, very frequent	hygroscoptic seeds, homeopathic, pharmaceutical
Geranium pusillum	Small geranium	*Geraniaceae*	1	not threatened, very frequent	pharmaceutical, most frequent geranium in the area
Geranium robertianum	Roberts geranium	*Geraniaceae*	1, 2	not threatened, very frequent	pharmaceutical
Geranium molle	Dovesfoot geranium	*Geraniaceae*	1, 2	not threatened, frequent	pharmaceutical
Hypericum perforatum	St. John's wort	*Hypericaceae*	2	not threatened, very frequent	nutrient-poor pointer, pharmaceutical, homeopathic, moderately phototoxic
Glechoma hederacea	Ground-ivy	*Lamiaceae*	1	not threatened, very frequent	ubiquist, pharmaceutical, wintergreen
Glechoma hirsuta		*Lamiaceae*	1		
Lamium album	White nettle	*Lamiaceae*	1, 2	not threatened, very frequent	homeopathic, pharmaceutical
Tilia sp.	Linden	*Malvaceae*	1		homeopathic, pharmaceutical
Oenothera biennis agg.	Primrose	*Onagraceae*	2		
Plantago lanceolata	Ribwood plantain	*Plantaginaceae*	1, 2	not threatened, very frequent	pharmaceutical
Plantago major	Broadleaf plantain	*Plantaginaceae*	1, 2	not threatened, very frequent	homeopathic, pharmaceutical
Platanus sp.	Plane tree	*Plantaginaceae*	2		
Arrhenatherum elatius	Bulbous oat grass	*Poaceae*	2	not threatened, very frequent, increase	
Bromus hordeaceus	Soft brome	*Poaceae*	2	not threatened, very frequent	

1 = found at BME, 2 = found at GWE, bold typeface indicates problematic invasive species/neophytes.
*Information gathered from: Metzing et al. (2018). **Information gathered from: Cordes et al. (2006).

Species	**Trivial name**	**Family**	**Location**	**Red List comments***	**Atlas of fern and flowering plants of the Weser-Elbe-area***
Bromus sterilis	Barren brome	*Poaceae*	1, 2	not threatened, very frequent, sig. increase	
Calamagrostis canescens	Purple small-reed	*Poaceae*	2		
Calamagrostis epigejos	Bushgrass	*Poaceae*	2	not threatened, very frequent, sig. increase	
Calamagrostis purpurea		*Poaceae*	2		
Calamagrostis spp.		*Poaceae*	1	not threatened, frequent, moderate decline	
Calamagrostis stricta	narrow small-reed	*Poaceae*	2	threatened, rare	
Dactylis glomerata	Cock's foot	*Poaceae*	1, 2	not threatened, very frequent	nitrogen pointer
Festuca rubra	Red fescue	*Poaceae*	2	not threatened, very frequent	
Holcus lanatus	Tufted grass	*Poaceae*	2	not threatened, very frequent	
Holcus mollis	Creeping soft grass	*Poaceae*	1	not threatened, frequent	
Hordeum sp.		*Poaceae*	1		
Lolium perenne	Perennial ryegrass	*Poaceae*	1, 2	not threatened, very frequent, sig. increase	pharmaceutical
Poa annua	annual meadow grass	*Poaceae*	1, 2	not threatened, very frequent	most common grass in the area, nutrient pointer
Triticum aestivum	Common wheat	*Poaceae*	1, 2		agricultural plant
Polygonum aviculare	Common knotgrass	*Polygonaceae*	1	not threatened, very frequent	pharmaceutical
Rumex acetosa	Common sorrel	*Polygonaceae*	2	not threatened, very frequent	edible (high Vit. C) but weakly poisonous (oxalic acid), pharmaceutical
Rumex acetosella	Red sorrel	*Polygonaceae*	2	not threatened, very frequent	pharmaceutical
Rumex crispus	Curly dock	*Polygonaceae*	1	not threatened, very frequent	poisonous for livestock, pharmaceutical, homeopathic
Aria edulis	Whitebeam	*Rosaceae*	1		
Crataegus rhipidophylla agg.	Hawthorn	*Rosaceae*	1, 2	(potentially rare)	
Geum urbanum	Wood avens	*Rosaceae*	1	not threatened, very frequent	pharmaceutical, seasoning
Potentilla argentea	hoary cinquefoil	*Rosaceae*	2	not threatened, frequent	pharmaceutical
Potentilla recta	Sulphur cinquefoil	*Rosaceae*	2	not threatened, very frequent	homeopathic, pharmaceutical
Pyracantha crenulata	Nepalese firethorn	*Rosaceae*	2		
Rosa canina	Dog rose	*Rosaceae*	2		fruits used for marmalade and tea, homeopathic, pharmaceutical

1 = found at BME, 2 = found at GWE, bold typeface indicates problematic invasive species/neophytes.
*Information gathered from: Metzing et al. (2018). **Information gathered from: Cordes et al. (2006).

Species	Trivial name	Family	Location	Red List comments*	Atlas of fern and flowering plants of the Weser-Elbe-area*
Rosa rugosa	Rugosa rose	*Rosaceae*	2		**neophyte, fruits used for marmalades and wine, pharmaceutical, management needed**
Rubus caesius	European dewberry	*Rosaceae*	2	not threatened, very frequent	pharmaceutical
Rubus fruticosus agg.	Blackberry species complex	*Rosaceae*	2		
Sorbus sp.		*Rosaceae*	2	(potentially rare)	
Acer pseudoplatanus	Sycamore maple	*Sapindaceae*	2	not threatened, very frequent, sig. increase, high accountability	good wood
Acer sp.	Maple	*Sapindaceae*	2		
Saponaria officinalis	Common soapwort	*Saponaria*	2	not threatened, frequent	saponins, pharmaceutical, homeopathic
Lycium barbarum	Chinese wolfberry	*Solanaceae*	2		**invasive**
Urtica dioica	Common nettle	*Urticaceae*	1	not threatened, very frequent	edible, fibre and dyeing herb, important caterpillar plant, pharmaceutical

1 = found at BME, 2 = found at GWE, bold typeface indicates problematic invasive species/neophytes.
*Information gathered from: Metzing et al. (2018). **Information gathered from: Cordes et al. (2006).

David J. Torne

Urban Tree Connectivity in the Lindenhof District of Bremen: An Overview and Proposal for the Analysis of Trees

1. Introduction

The ecological connectivity of urban environments has great influence on the biodiversity and health of the ecological communities that reside in them. The ecological and social value of urban vegetation is widely recognised and should be an intrinsic part of how we observe and organize our cities. Trees play a major role in defining the structural connectivity of urban spaces (Von Thaden et al., 2021). Furthermore, current research shows how localized small-scale greening actions can have large positive ecological changes (Mata et al., 2023).
In the city of Bremen, large parts of the urban vegetation are dealt with by Umweltbetrieb Bremen (Bremen Environmental Company, UBB). UBB takes care of vegetation around streets, most public green areas such as cemeteries, playgrounds and kindergartens, but not green inside roads (such as in traffic refuges which are dealt with by the street and traffic office ASV [Amt für Straβen und Verkehr]). In many cases, care by UBB is provided in the name of other departments (such as the education department), or alongside other organizations such ASV. In total, the UBB tree registry already accounts for 73000 street trees and 152000 trees in other green areas. Large parts of UBB's responsibilities can be traced in the GeoPortal Bremen, which provides the public with access to data regarding all the street trees in the city; additional data are stored in the Green Informations System (GRIS) where access is limited. The data UBB has on the trees within the city could be a great tool to better understand the ecological connectivity within the city. To make effective use of them in terms of analysis and interventions, the data used should be as complete as possible. However, we identified three major issues that could be improved upon for this to be the case in the UBB database. Information regarding the urban vegetation is incomplete, inaccessible, or absent with regard to:

1. The trees on private ground;
2. the (admittedly complex) barrier effects in the urban environment; and
3. non-tree vegetation, like shrubs or herbs.

In an attempt to reduce these data gaps, this project takes the Lindenhof district in Gröpelingen (Bremen) as an example. We recorded all the trees present and analyzed the coverage of the data present on the basis of the methodology described below. Then, we reviewed ecological connectivity as it refers to distance and major barrier effects. From there, we make a proposal to improve upon the currently accessible data.

2. Urban Ecological Connectivity

The biodiversity of an area accounts for all species in that given area. This includes not only vegetation but also animals, fungi, lichens and all other life forms, including microorganisms. For this project we focus on tree vegetation, not because it accounts for a larger part of the species but because of two factors. Firstly, a larger amount of species depends on the arboreal stage of an ecosystem than most other groups of organisms. Consequently, trees play an oversized role in the connectivity of ecosystems. Without trees and other woody vegetation in an urban environment, connectivity decreases by 97% (Von Thaden et al., 2021), and isolated trees alone contribute to 27% of the connectivity.
The ecological connectivity within an urban environment is essential to understand the green spaces within it. Previous research (Ossola et al., 2019; Von Thaden et al., 2021) show how trees including isolated trees have a strong effect on the structural connectivity of urban green areas. Additionally, connectivity should take into account all forms of vegetation, classified as grasses, shrubs and woody vegetation. For this project, however, only trees are analyzed because of their particular importance to overall structure and connectivity of the vegetation of urban spaces.

A special problem of tree-related connectivity within urban environments is the existence of buildings and other physical barriers separating them. Urban vegetation is usually analyzed by what is known as Normalized Difference Vegetation Index or NDVI. NDVI works based on the properties of the chlorophyll in plants (GISGeography, 2023), by looking at the difference between the near-infrared light, which chlorophyll strongly reflects, and red light, which chlorophyll absorbs. If an area reflects a lot of near-infrared light and very little red light, that means there is a lot of chlorophyll present and thus dense vegetation. The values for NDVI range from +1 to -1. Values closer to 1 represent more vegetation, values around zero are likely to be urbanized areas and values closer to -1 are usually bodies of water.

One of the disadvantages of this NDVI approach however is that NDVI can not distinguish low surfaces such as pavement from tall structures such as houses that would impede connectivity. For this, another remote sensing technology can be implemented. LiDAR (Light Detection and Ranging) has been shown to be able to measure the height of trees and other structures (Hancock et al., 2017). Combining NDVI with LiDAR data (Rocha et al., 2017; Donovan et al., 2019) allows researchers to create 3D maps of urban spaces to better study their functional connectivity. In the case of Bremen, a project called Bremen 3D already exists and is made publicly available by the Bremen State Office of Geoinformation (Landesamt Geoinformation Bremen). This project provides 3D-data for the buildings in the city, which is crucial to understanding the scale of the impact barrier effects plays in our scenario.

3. Major Barrier Effects

Barrier effects refer to anthropogenic land use forms and structures obstructing or impeding the flow of energy, information or matter across the ecological matrix (Marulli et al., 2004). When the matrix is fragmented by barriers, the factual ecological niche of its populations is reduced. The smaller populations have access to a more limited amount of resources and can not interact effectively. This effect can not be easily measured or quantified, and must take into consideration the type of barrier, the distance impact, and the adjacent land use and vegetation types (Marulli et al., 2004). Knowing where these barriers are can help to address related challenges and complement other strategies, such as corridor mapping, for broadening the range of alternatives available to conservation practitioners (McRae et al., 2012).

To better visualize the importance of having access to data that represent these abiotic barriers and the impact they have on connectivity, we will look at an example in Bremen's Lindenhof district. In figure 1 we can observe some trees that are situated behind the large apartment block Hirschberger Str. 15-37. The tree in the red circle is roughly 30 meters away from all the other trees. However, the trees in the Bürgermeister-Ehlers-Platz marked here in yellow, and the tree in the blue circle to the other side, are both separated from the tree in the red circle by the surrounding building that is about 17 meters high. Because of this, connectivity is more likely established with the tree marked in purple, and all the vegetation connected to it. As we can see in this example, data about the biotic factors of the vegetation and the distance between them should be supplemented with data about the abiotic environment. Moreover, in this example the trees in the yellow and blue circles are street trees managed by UBB and present in the GeoPortal

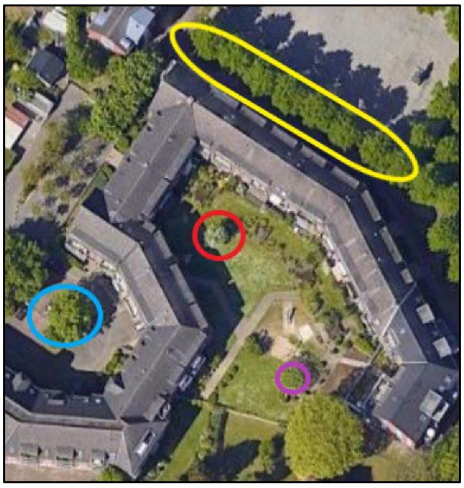

Figure 1: Trees and separating buildings adjacent to Bürgermeister-Ehlers-Platz.

database. But since the red and purple trees are on private grounds, they are not included in any official database, to our knowledge.

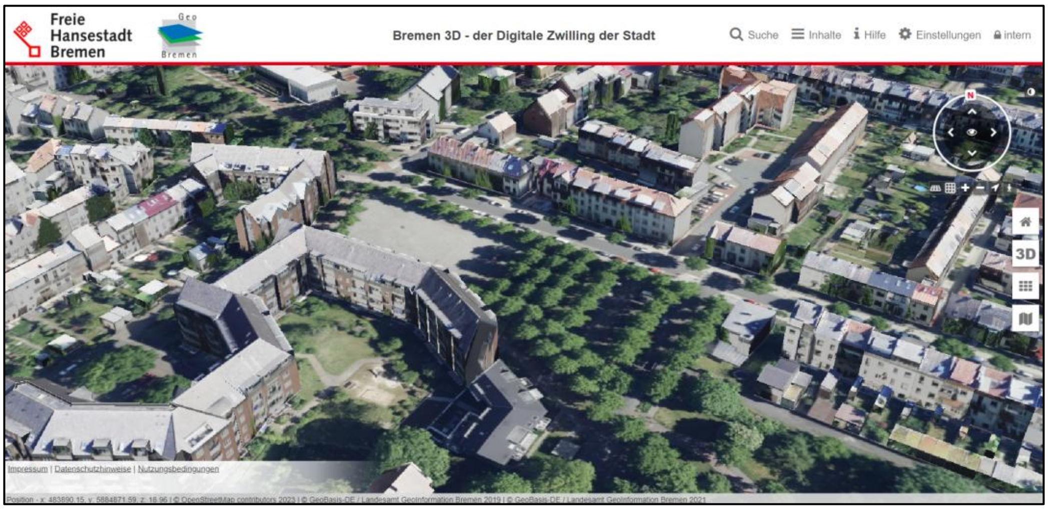

Figure 2: Bremen 3D project showing the space to the Southwest of Bürgermeister-Ehlers-Platz.

The building data from the Bremen 3D lets us know the buildings are 17 meters high. The trees in yellow and blue are 15 and 14 meters tall respectively. However, both databases are completely separate and neither of them is comprehensive. As it can be seen in the screenshot Figure 2, in the center foreground one building is missing from the 3D rendering, and no trees are present in some parts of the 3D project. The tree in the red circle from Figure 1, e.g., has disappeared.

4. Materials and Methods

For this project we developed a map of all the trees in the Lindenhof district and in a 200 meter perimeter around it. This map distinguishes the trees into 3 groups: Trees recognized as street trees by the GeoPortal website, which are maintained by the Umweltbetrieb Bremen (UBB); trees maintained by UBB but not registered in the GeoPortal (which we derived from GRIS); and so far "unrecognized" trees, largely on private grounds.

The map was generated using QGIS3 software (QGIS.org, 2021). We took raster images of the area from Google Earth Pro (Google Earth Pro 7.3.6.9345 [2022]), and the trees were identified individually by contrasting the images with Google Maps, Google Earth and Google street view to determine where the trees were located and to differentiate trees from bushes and other vegetation. Since Google Earth Pro provides a 3D map of all the trees in the area, this has been the main tool when comparing and determining the limits of tree coverage in most unclear cases.

The GeoPortal was contrasted to determine which category each tree corresponded to. From the website, we determined which trees were classified as street trees and which were found under UBB maintained areas. Not all UBB maintained areas were recognized as such on the GeoPortal so they were contacted directly to help locate schoolyards, kindergartens and other green spaces. Because of this approach, the distinction between tall bushes and short trees was simply an estimation, and might be inaccurate in a few instances. In most cases, however, we had good results in using the 3D model view of Google Earth Pro to compare the shape and height of the tree/bush in question against other vegetation nearby that was part of the UBB database and of which it was clear it was a tree. The methodology described was developed by the author of this report (D. Torné Vega) and discussed with members of the larger research project.

5. Results

All trees were digitized as a total of 1150 polygons. These are composed by 350 street tree polygons, 178 UBB tree polygons and 622 private tree polygons. It is important to remember that the number of polygons is not perfectly representative of the number of trees in each category. In figure 3, the trees are represented in these 3 categories. The trees of the Bürgermeister-Ehlers-Platz are street trees managed by UBB, they have their year of planting, age, height, species and diameter publicly available on the GeoPortal website. The trees south east of the square, colored in yellow are part of a green area surrounding a public kindergarten. These are managed by UBB as well, but their information is not available on the public GeoPortal website. Finally, the groups of trees west of this last group, and to the north, are colored in green, and these are private trees mostly found in gardens of private homes and, to our knowledge, they are not represented by UBB or otherwise available in official databases that are easily accessible.

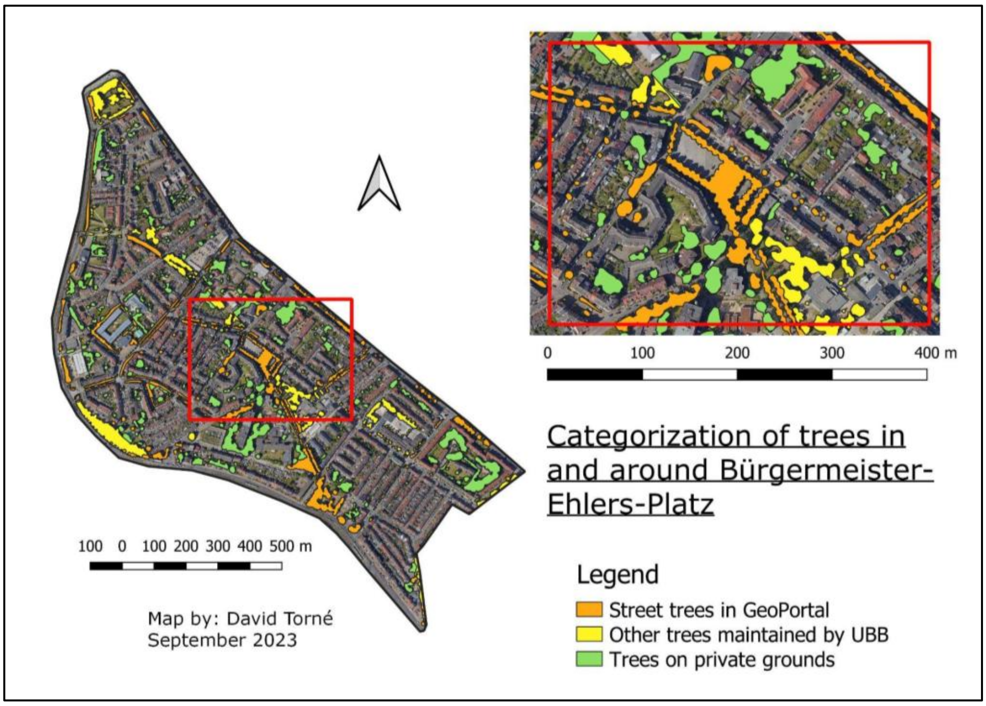

Figure 3: Map of trees in the Lindenhof district categorized by responsibility and ownership with a focus around the area of Bürgermeister-Ehlers-Platz

These three groups of trees are managed separately, and to our knowledge UBB has no data - and certainly no direct responsibility - for the private trees. Yet, obviously, these three different groups of trees are ecologically indistinguishable and connected. Generally speaking, we observed that street trees are more likely to be single trees or lines of trees of medium size that can serve as ecological corridors for insects and birds. Private trees in the area are more likely to be smaller trees separated from the rest by buildings and other barriers. Finally, the other trees represented in GRIS are usually in green areas (Grünanlagen), they are larger and physically very close to one another forming large dense areas. However, these are just trends.

Figure 4, additionally shows the physical proximity of these trees. A distance of 5 meters was chosen based on the 2021 study by Bar et al. (2021) from Stockholm University. The study on spatial connectivity and urban insect communities focused on oak trees and analyzed their connectivity based on 2 factors: distance and barriers. From every tree, the authors looked for trees that could be seen within a range of 50 meters, then in a range between 50 and 100 meters, and finally trees more than 100 meters away. The study excluded trees that were not visible from the other trees because of physical barriers, and trees smaller than 5 meters. However, in a second classification, a distance from 5 meters from the edge of the crown was chosen to any other tree or structure to categorize the trees as open, almost open or half-open. In our case, we only used this distance: if we had chosen distances of 50 meters or more, the entire district would have appeared as connected. However, this would not consider the important physical barriers that separate trees in this urban environment. Because of this, and the limited availability of 3D data for these barriers, we selected the 5 meter area of influence in our attempt to document how large sections on our map are ecologically connected and can likely serve as corridors for a number of different species.

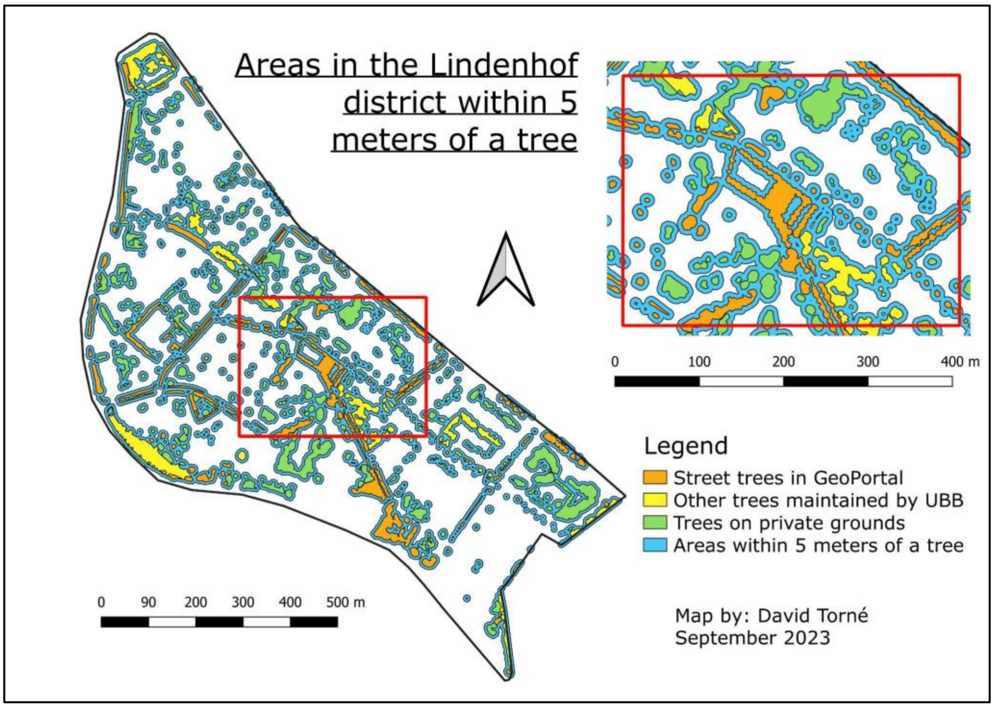

Figure 4: Trees in the Lindenhof district categorized by responsibility and ownership. The color blue represents the area within 5 meters from a tree of any category.

Lastly, we wanted to show how this connectivity extends beyond Lindenhof, so a 200 meter perimeter around Lindenhof was also analyzed. This data is presented in Figure 5. The first notable area is the large dense patch of UBB trees south-east of Lindenhof. This is the Friedhof Walle, a large cemetery, where most of the vegetation (including trees) is also managed by UBB. To the north-east we also find a large green corridor (the Grünzug West) with many trees pertaining to a public green area. These two large green areas probably serve as the main points of external ecological connectivity for the district of Lindenhof. However, our map indicates that not all areas around the district are equally well connected.

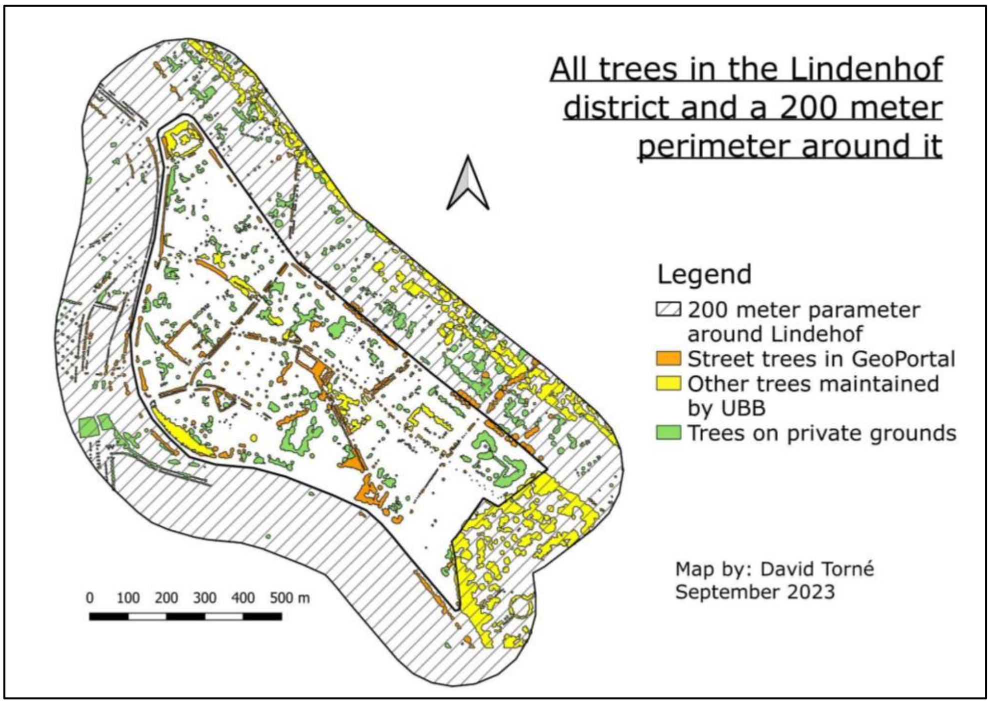

Figure 5: Map of trees in the Lindenhof district and connected green spaces in a 200m perimeter.

6. Proposal

The approach commonly taken to combine vegetation data with the physical data of barriers is to measure both separately and then combine the data. This is usually done by locating and measuring the arboreal stage through NDVI, and measuring the abiotic barriers through LiDAR. In the case of Bremen, the UBB website already includes a project called 3D Bremen (Figure 2), which includes the 3D model for most buildings in the city. However, this dataset does not include the height or physical size of these trees. For the trees under UBB supervision, street trees or otherwise, UBB already has data regarding their height and crown diameter.

To improve the currently available data, we propose an NDVI scan to be taken of the area of interest. Then the NDVI values of the trees for which we know the size can be compared to the NDVI values on private areas. Through this comparison we can estimate the size of the trees on private land. Combined with the data from the Bremen 3D project this can then be used to generate an accurate representation of the arboreal matrix. This representation of the matrix can foster our understanding of the ecological connectivity in (and of) the district to then carry out further research, apply protection where necessary, and, last not least, develop greening interventions in the area so as to maximize their ecological impact.

Thus, this proposal shows a way forward how we can address the three major issues identified in the beginning of this report: include the trees on private ground in our database; identify potential barrier effects in the environment; and also help us locate non-tree vegetation such as shrubs or herbs, making use of NDVI data. NDVI also provides data to where the private trees are located and an estimate of their size. Finally, including data from the 3D Bremen project helps us to better understand and locate potential barrier effects.

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Lena Wende

Use of Urban Green Spaces in Socio-economically Disadvantaged Urban Districts: An Observational Study in Gröpelingen, Bremen

1. Introduction

The attention towards social aspects of urban green space is growing, with increasing publication numbers at least since the early 2000s (Kabisch et al. 2015, 27). Due to developments such as growing social inequalities, progressing climate change, and increasing urbanization, the importance of urban green spaces and the issue of equitable access to them have increasingly come into focus in interdisciplinary research, policy, and science (cf. Wolch et al. 2014; Kabisch et al. 2015). International organizations such as the World Health Organization (WHO) and the United Nations (UN) emphasize the fundamental role of urban green spaces in creating livable, inclusive, and healthy cities. Accordingly, they advocate for the expansion and improvement of green infrastructure as an essential component of sustainable urban development worldwide (cf. e.g. WHO 2017; UN 2015). This focus on urban green space is also reflected in political frameworks such as the EU Strategy on Green Infrastructure (European Commission 2013), Sustainable Development Goal 11 (UN 2015), and the German White Paper on Urban Green "Weißbuch Stadtgrün" (BMUB 2017), where the promotion and enhancement of green spaces is anchored at both, the local and international levels. In addition to creating health-promoting environments, urban green spaces are widely recognized for their contribution to promotion of biodiversity, their ecological functions - such as climate regulation, noise reduction, and air purification - and their support for social interaction and integration. Moreover, they offer economic benefits, including increased property values in proximity to green spaces (cf. BMUB 2015; Kabisch et al. 2015). Against the backdrop of global challenges, green spaces represent essential places of balance and recreation, particularly for vulnerable social groups (BMUB 2015, 7).

However, the distribution of urban green spaces within cities - regarding their quantity, accessibility, and quality - is highly unequal. In many cities, socioeconomically disadvantaged communities – neighborhoods that are often disproportionately affected by public health challenges – tend to have limited access to well-maintained parks and green spaces, making the distribution of urban green spaces a key issue of environmental justice (cf. Wolch et al. 2014, 239; Haase 2023, 159). Numerous studies have demonstrated a clear spatial correlation between low socioeconomic status, increased environmental burdens, and limited access to green spaces (Böhme & Franke 2021, 71). It has therefore been argued that urban green spaces must be better adapted - both quantitatively and qualitatively - to meet the challenges of the present and the future (ibid., 12) and that, in order to align the potential of urban green spaces with the needs of diverse user groups through urban planning interventions, the data basis for the provision of urban green spaces has to be systematically improved at the national level (Rusche & Fina 2019, 212). Accordingly, the scientific literature emphasizes the importance of incorporating the actual usage behavior of the urban population into the analysis and evaluation of green space provision and of responding to these findings with targeted and needs-based measures (ibid., 216).

Against this background, the present study aims to make an empirical contribution to the discourse on the use and quality of urban green spaces in the context of social and environmental inequality. Using the example of the socially disadvantaged district of Gröpelingen in Bremen, the study investigates how local residents use a particular urban green space and to what extent conclusions can be drawn regarding environmental justice and social inclusion. A qualitative observational study is employed to analyze the usage behavior of different social groups and to gain insights into the actual utilization of urban green spaces in everyday life. At the same time, this study contributes to the methodological advancement of urban research by complementing traditional, indicator-based analyses of green space provision with usage-oriented perspectives. In this context, it raises the question of to what extent observational studies can serve as a meaningful tool in urban research to expand existing approaches to environmental justice by incorporating patterns of real-life usage behavior.

2. Public urban green: functions, inequalities and monitoring

Various synonyms and definitions are frequently used for urban green spaces in both academic and public discourse. Kabisch et al. clarify in their systemic overview that in international discourse “urban green space is defined as a range of parks, street trees, urban agriculture, residential lawns, and roof gardens” (2015, 26). Furthermore, Wolch et al. state in their overview of the Anglo-American literature on urban green space: “Such green space is diverse, varying in size, vegetation cover, species richness, environmental quality, proximity to public transit, facilities and services” (2014, 234). The BMUB in Germany defines urban green as any type of green open space and green buildings (2015, 7), which do not have to be created exclusively through urban planning measures. Accordingly, urban brownfield sites and open spaces are also considered a form of urban green that fulfill important functions of urban green (Hansen et al. 2012, 14). Brownfield sites are generally subject to natural succession, whereby the green has grown spontaneously due to the fallow stage. Some areas are appropriated by residents for leisure and recreational purposes (ibid.). As outlined in the introduction, the health-promoting and restorative effects of urban green spaces are among their most widely recognized benefits (cf. WHO 2017; Ammon & Langenbrinck 2022, 24ff). Both physical and mental well-being are supported by near-natural residential environments and improved living conditions (ibid.). Spending time in green spaces close to residential areas can reduce stress, promote health through physical activity and exercise, and help prevent chronic diseases (BMUB 2015, 13). Moreover, green spaces contribute to reducing environmental pollution, such as particulate matter and exhaust emissions, and help improve air quality. Urban green areas also serve as places of encounter, communication, and integration (Willen 2020,720). Public green spaces bring together people of different ages, backgrounds, and genders, facilitating social interaction and shared use (Ammon & Langenbrinck 2022, 26). Consequently, urban greenery has a positive impact on neighborhood cohesion, residents’ identification with their living environment, and opportunities for experiencing nature (BMUB 2015, 13).

However, due to the social, economic, and ecological inequalities to which residents of disadvantaged neighborhoods are exposed, these populations have specific needs for access to nature and green spaces (Böhme & Franke 2021, 71; Wolch et al. 2014, 239). People living in socially marginalized areas are disproportionately affected by noise pollution, bioclimatic stress, and air pollutants - such as particulate matter, NOx, CO2 - while simultaneously having access to fewer green and open spaces as a means of environmental compensation (ibid.). As a result, they face an elevated risk of negative health outcomes (Deutsche Umwelthilfe e.V. 2017, 6). In addition, language barriers and high levels of unemployment often lead to increased social isolation and loneliness. These factors create significant obstacles for residents in establishing social connections within their communities and gaining access to the labor market (Davis et al. 2021,12). In academic discourse, such inequalities - along with issues of accessibility, availability, and the quality of green spaces in socioeconomically disadvantaged neighborhoods - are discussed under the concept of environmental justice (Willen 2020, 724). This term refers to an interdisciplinary concept (Elvers 2011, 464) that brings together discourses on urban quality of life, social justice, equal health opportunities, and biodiversity (Haase 2023, 160). The overarching goal of environmental justice in politics and urban planning is to create a fairer and more sustainable society in which all people can equally benefit from a healthy and livable environment through access to green spaces (Böhme & Franke 2021, 71). German studies have shown that the distribution and accessibility of urban green spaces are characterized by inequalities. The green space deficit is particularly pronounced in poverty-stricken urban districts (BMUB 2015, 41). In these disadvantaged neighborhoods, the average green space per capita amounts to only 38 square meters, which is significantly below the national German average of 50 square meters (ibid., 70f). These challenges illustrate that socially marginalized areas have a particularly high need for development.

The Deutsche Umwelthilfe assumes that the qualitative enhancement, redesign and creation of new open green spaces can be an important factor in urban regeneration and in strengthening social cohesion in disadvantaged urban districts. Such measures can contribute significantly to improving health, quality of life, and social interaction (2017, 6). To integrate environmental justice into municipal policy-making, the systematic assessment of urban environments constitutes a fundamental basis for identifying and mitigating health-relevant environmental burdens (Böhme et al. 2015, 133). Based on the results of green space monitoring, political decisions on intervention measures are made and areas in need of funding are identified. The authors Rusche and Fina emphasize that the supply-side analysis of green space provision must be complemented by a user perspective and appropriate indicators in order to provide a more accurate representation of the actual conditions of urban green spaces and their usage (2019, 211). Although existing research has mainly addressed the spatial extent and proportion of green and urbanized areas, it frequently overlooks the service quality of green spaces for users and their real-world usage patterns (ibid., 214). Accordingly, conventional models of urban green space analysis are criticized for their insufficient consideration of temporal usage patterns, frequency of use, and interactive social behaviors within these spaces (ibid.).

3. Case study: Gröpelingen, Bremen

The Bremen district of Gröpelingen represents a relevant empirical case in which the interrelations between social disadvantage and environmental inequality become apparent. The population of this district exhibits above-average rates of cardiovascular diseases, addiction disorders, exposure to environmental stressors, and stress-related illnesses (Davis et al. 2021, 10). These health outcomes may be associated with structural deficits in the availability and quality of recreational and green spaces, as well as with the area's broader socioeconomic vulnerabilities. Significant differences in the provision of green and open spaces were also identified within the city of Bremen (Umweltbetrieb Bremen 2011, 27). The uneven distribution of urban greenery at district level is equally an indicator of exacerbated socioeconomic differences and environmental pollution problems (BMUB 2015, 71). The study area selected for this study lies in Gröpelingen and is an urban brownfield site covering approximately 1.3 hectares. It is located between the nearly completely sealed 52-hectare industrial area of Riedemann-/Reiherstraße and the residential complex Wohlers Eichen (SWAE 2021, 1). Former railway tracks, currently unused and traversing the brownfield site, form a branching extending from the residential area into the industrial area. These tracks are utilized by local residents as a pathway, which is covered with worn carpets. Additional evidence of informal appropriation of this green space includes the presence of a treehouse, remnants of a tire swing, and localized litter deposits (ibid.). Due to its mode of formation, this green space represents a naturally developed brownfield site (cf. Hansen et al. 2012, 14). Despite the absence of formal amenities such as seating, designated pathways, or lighting, the observed traces of human appropriation suggest a regulated utilization of the brownfield site for recreational and leisure activities. Moreover, this area is incorporated within the framework of the project titled "Urban Climate Forest Park for the Enhancement and Promotion of a Work and Residential Location," led by the Senator for Economy, Labour, and Europe (SWAE). This initiative seeks to mitigate spatial conflicts arising from the close proximity of residential and commercial zones, address issues related to pollution and surface sealing of the brownfield site, and compensate for the deficiency of designated recreational facilities (SWAE 2021, 2). The district of Gröpelingen, in which the study area is located, is significantly shaped by socioeconomic, structural, and demographic challenges. These issues are manifested in an above-average unemployment rate, a high proportion of welfare recipients, substandard housing conditions, and low educational attainment within the district (cf. Statistisches Landesamt Bremen; Hillmann & Rohmeyer 2012, 82). The identified socioeconomic and structural deficiencies are particularly evident in the eight-storey residential complex Wohlers Eichen (IWS 2006, 8). This linear block building, comprising 250 residential units and housing approximately 1,100 residents, represents one of Bremen's 14 designated WiN areas (Wohnen in Nachbarschaften, "Living in Neighbourhoods") and has been addressed in the Integrated Urban Development Concept (SUBV 2014, 9).

4. Observational study

To comprehensively investigate the actual patterns of use within the study area and to obtain exploratory findings, an observational study was conducted. This methodological approach positions the urban environment and its inhabitants as an "observable laboratory," thereby allowing for the empirical examination of everyday practices (Eckardt 2014, 177). This urban research methodology is typically used to observe people or certain marginalized groups in public spaces such as urban districts (Thierbach & Petschick 2014, 855). To this end, the researchers conducting the observations immerse themselves in the study site and collect data through deliberate and systematic perception of actions, social relations, usage patterns, and interactional dynamics (ibid.). The observational method facilitates access to the research field beyond linguistic barriers, allowing for the identification of cultural practices conveyed through non-verbal forms of expression and body language - dimensions of social life that often elude purely language-based discourses (Münst 2004, 334).

For this study, a participant, structured observation approach was employed in the natural setting, not as actively hidden or covert observation, but without formal disclosure. By using this approach, the study aimed to minimize observer bias and reactivity effects, thereby enabling the collection of naturalistic and context-sensitive qualitative data (Eckardt 2014, 177f). Close immersion in the field allowed for the identification of social dynamics, informal social structures, and everyday practices that are typically inaccessible through surface-level observation (Münst 2014, 334). Nevertheless, the possibility remains that the mere presence of the researcher within the field - even in an undisclosed role - may elicit an observer effect, potentially influencing participants' behavior and leading to a restriction or alteration of certain actions (Gold 1958, 220f).

In this study, priority was given to the analytical depth and contextual relevance of the data rather than to the statistical representativeness or size of the sample (Akremi 2022, 410ff). Accordingly, theoretical sampling was employed to select the observation units (Döring & Bortz 2016, 302). Variation across days of the week and times of day served as the primary sampling criterion, with the aim of capturing a broad spectrum of usage patterns of the green space. Based on these criteria, five observation sessions were conducted, each covering afternoon and evening usage periods. Data collection took place between July 25, 2023, and August 3, 2023. Duration of each field observation session was deliberately limited to two hours in order to maintain the observers' concentration and focus throughout the data collection process (Thierbach & Petschick 2019, 861). To systematically capture the real-life usage of the brownfield site, a coding scheme comprising action- and actor-centered categories was developed to facilitate the differentiation of observed behaviors and social practices (Eckardt 2014, 181). Further differentiations were applied to delineate specific activity types and user typologies (cf. Table 1). Additionally, temporal parameters such as duration of stay and directional trajectories of users were recorded to elucidate recurrent usage patterns. Interactional modalities constituted another key analytical dimension, with detailed multi-dimensional coding applied to classify the diversity of social exchanges documented in the observation protocols. It is important to recognize that users often engaged in several activities and types of interactions at the same time, showing flexible and overlapping patterns of behavior.

Categories	Differentiations				
Gender	male		female		
Age group	children	adolescents	adults	seniors	
Duration of stay	length of stay (in minutes)				
Activity	recreation	walking through	using play area	experiencing nature	walking the dog
Interaction	none	greeting	conversing	smartphone use	playing

Table 1: Observation differentiations

To ensure a detailed documentation of the data collected in the field, field notes were recorded immediately after each observation session using both audio recordings and written notes, which were systematically categorized according to the predefined coding scheme (Thierbach & Petschick 2019, 863). The transcribed observation protocols serve to capture the fleeting and ephemeral nature of in situ experiences by means of descriptive texts and categorical coding. These protocols include descriptive metadata such as the date of observation, duration, weather conditions, and the number of individuals observed (Merklinger 2022, 49). Subsequently, the observed subjects and their behaviors are comprehensively described using the established categories and differentiations, alongside initial interpretative reflections.

5. Results

The conditions of the observational study were characterized by variable weather, alternating between precipitation and sunshine, as well as passing thunderstorm fronts. Over the course of 10 hours of observation, a total of 24 individuals using the area in various ways were recorded. The number of observed users varied significantly across observation sessions. The first sampling session, conducted on Tuesday from 5:00 p.m. to 7:00 p.m., documented the highest number of users (eleven individuals), whereas only a single person was observed during the Saturday session from 2:00 p.m. to 4:00 p.m. During the remaining three sessions, two (Friday evening), three (Thursday midday), and seven (Thursday afternoon) different individuals were recorded, respectively. Sixteen of the observed users were identified as male and eight as female. Regarding age groups, adolescents and adults were noticeably more present in the use of the brownfield site, each accounting for approximately 38% of all users observed (nine individuals each). In contrast, children and seniors each constituted only about one quarter of the total observed visitors, with three individuals in each group.
Based on the processed observational data of all recorded activities during the investigation of the green space, a significant trend in usage patterns was identified. Slightly more than half of the observed individuals primarily used the green space as a walking through route between the residential and commercial areas. Furthermore, observations indicated that most users were residents of the Wohlers Eichen housing complex. The second most common form of use, accounting for 19%, was walking the dog. Additionally, 13% of the observed individuals used the green space for recreation, spending extended periods there by sitting on self-made benches or on the grass. The green space was least frequently used for experiencing nature or as a play area by children. Users classified under experiencing nature engaged more closely with the natural environment during their stay by activities such as picking and eating wild blackberries or photographing wildflowers and insects. The green space was observed to be used as a play area only once during the study, by two children. The dominant use as walking through also influenced the length of stay of the individual users, which was typically less than 10 minutes. In contrast,

individuals who used the area for recreation tended to stay for longer periods. Moreover, the observations offer insights into the preferences and needs of different age groups regarding green space use. However, since the age groups children and seniors were underrepresented in this observational study, the data do not allow for representative conclusions about the general population's use. Nonetheless, preferences for the green space use among adolescents and adults could be identified. Here, the high proportion of walking through is emphasized once again, with this activity accounting for 80% of total use within the adolescent age group. Among adults, a more diverse distribution of forms of use was observed. While other age groups outside this range practiced only two forms of use, adults engaged in four of the defined activities. The most frequent adult activity was walking the dog, followed by walking through. Furthermore, adults were the only age group recorded engaging in experiencing nature during the observation period.

The individual interaction patterns observed among users were less pronounced compared to the activity categories. Nevertheless, the interaction type conversing was the most frequently observed, accounting for 37% of all documented interactions. The type of interaction with each other was influenced by whether the green space was visited alone or in company. Accordingly, around 23% of all individuals did not interact with each other at all. An equally large proportion of the observed interactions was categorized as smartphone use. This interaction type was frequently observed both among individuals and within groups, where smartphones were used for phone calls, photography, or messaging. The least frequently documented forms of interaction were greeting and playing. The latter was exclusively observed in the context of the green space being used as a play area, which, during this study, occurred only once, when two children played together. As with the activity patterns, an attempt was made to analyze the interaction patterns across the different age groups. However, meaningful comparisons and generalizations remain limited due to the uneven sample distribution, where adolescents and adults were observed approximately three times more frequently than children and seniors. Consequently, no representative conclusions regarding the interactional preferences of specific age groups can be drawn from the available data. Nonetheless, the limited observations of children and seniors did yield some insight into their interactional behavior. None of the observed seniors engaged in social interactions with others or with the environment. In contrast, adults were the only age group observed engaging in greeting behavior. The majority of smartphone users were recorded among adolescents.

6. Discussion

By synthesizing the observational data, a few conclusions can be drawn regarding the actual usage of the brownfield site in Gröpelingen, as well as the usage preferences of different user groups. Based on the observed frequencies of green space use and the categorized activities of users, the intensity of utilization of this brownfield site can be characterized as a form of occasional spontaneous use, or moderate use by residents, children, and dog owners (cf. Rebele 1996, 291). The classification of the study area can be further substantiated by the fact that this urban green space, originally an industrial brownfield site, has been informally appropriated by residents of the adjacent housing block, as evidenced by the presence of desire paths and localized littering. Moreover, recurring patterns of use were identified through the observational study. In particular, the repeated observation of the same individuals traversing the green space with their dog during two separate observation sessions may be interpreted as an indication of a regularly used walking route. Furthermore, the observed patterns point to occasional to moderate usage of the brownfield site, as only a small number of individuals were present during individual observation sessions. Particularly striking was the low level of use recorded on the observed Saturday. It had initially been hypothesized that usage frequencies would be especially high during the weekend and school holiday, when most working residents are off duty. However, this assumption was not supported by the data, as this session recorded the lowest number of users. The brief duration of stay for most individuals further indicates occasional or moderate rather than intensive usage, which would typically be characterized by regular, prolonged visits (ibid.). Additionally, the previously mentioned variable weather conditions likely contributed to the moderate utilization of the study site during the observation period.

When the different types of use were compared, it was found that half of the activities carried out in the green space were limited to crossing it. The area was also frequently used for walking dogs. These findings confirm Hansen et al.'s (2012, 26) assumption that informal green spaces are recognised by residents as usable open spaces and frequented primarily by walkers and dog owners. A high frequency of use by dog owners, children, and adolescents further suggests a lack of open spaces in the immediate vicinity that adequately meet the needs of these user groups (ibid., 27). Consequently, the observed usage of the green space by dog owners may indicate an undersupply of designated dog-walking areas in the vicinity of the Wohlers Eichen housing complex. By contrast, functions such as recreation and experiencing nature were found to play a significantly lesser role in the actual use of the area. One possible explanation for this may be that the quality of the green space or the expectations of the residents with regard to its usability are not being met. Possible contributing factors could include usage types such as vandalism or illegal dumping, which are facilitated by low levels of municipal and social oversight, and are incompatible with activities such as recreation and experiencing nature. For urban residents, such undesirable uses may lead to a lack of acceptance of the space, resulting in its diminished use for leisure purposes (ibid.). Visibly well-maintained and tidy green spaces are considered to be much more attractive for use than diverted vegetation development in brownfield sites (cf. BMUB 2015, 29ff). Furthermore, it was noted that, despite the requirement for green space to be used as a nature experience area being met, this was only the case in a few instances. The green/brownfield site is located in close proximity to the residential area (less than 300-500 meters away), is covered with urban wilderness, and spans approximately 2 hectares in size (Hansen et al. 2012, 27). Furthermore, design elements such as the absence of seating and resting facilities, such as benches, may have contributed to the limited duration of user visits (ibid.).

By interpreting the observed forms of use in relation to age groups, it is also possible to determine whether the qualities of the green space meet the needs of different target groups. According to this, children, adolescents, adults, and seniors have different needs that should be met by the diverse functions of urban green spaces (BMUB 2015, 27). In order to satisfy the dual imperatives of urban nature and the multifarious interests of the urban population, a range of differently designed areas is required. It is only through the implementation of a diversified area design that the requirements of urban residents can be met and that cities can be conceived as livable places (ibid., 28). The demands of different user groups on urban green spaces are reflected in their perception and, above all, their use of urban green spaces (ibid.). Since only three children and seniors could be recorded using the space during the observation study, this may indicate that this green space does not meet the needs of these groups, for example due to a lack of barrier-free access. The observation of the green space's surrounding environment revealed that, while a considerable number of children were outside, they occupied the playgrounds adjacent to the residential complex. Consequently, it can be concluded that the playgrounds in close proximity to residential areas are more conducive to the needs of children residing in these areas than the brownfield site. It was also observed that the adolescents pursued their needs for social interaction and sporting activities at the youth recreation center near the green space and repeatedly used the green space only as a passageway.

The analysis of observed interaction patterns also yielded insights into the qualities of the green space. A significant portion of the observations indicated that users either did not engage in social interaction at all or limited their interaction to smartphone use. The data revealed that the green space was not actively used as a meeting place for social gatherings. Instead, interactions primarily occurred within pre-existing social groups, with greetings exchanged between strangers being rare. In contrast to the functions attributed to green spaces as potential sites of neighborly encounters and interpersonal interaction (Ammon & Langenbrinck 2022, 26), the findings suggest that the study area was hardly used as a space for social exchange during the observation periods. When individuals visited the brownfield site, they typically did so alone and at different times, which limited opportunities for cross-group interaction between users of varying ages, genders, or backgrounds. The low level of social interaction may also reflect the limited recreational qualities of the site itself (Ammon & Langenbrinck 2022, 26f). Literature highlights that the mere presence of green spaces in residential environments is insufficient; rather, the design and amenities of such spaces play a crucial role in fostering social encounters (ibid.). Green spaces should therefore offer various opportunities that facilitate interaction among diverse user groups. Examples of such amenities include barbecue or fire pits, seating areas, or spaces designated for urban gardening.

7. Reflection and limitation

One of the main limitations of this study stems from the scope of the observational study. The termination of data collection was justified by a mix of different factors, including adverse weather conditions, a certain degree of saturation and practical research constraints. However, to further elaborate on the observed findings, a more extensive and systematic study could be conducted. Such an investigation could incorporate more in-depth sampling criteria, finer-grained observational differentiations, and a contextual analysis of the green space's surrounding environment (Thierbach & Petschick 2019, 861). The broad categorization scheme used in this study also left limited room for interpretations when classifying user activities and interactions. As a result, some individuals could not be clearly assigned to specific categories of activity or interaction, since their behaviors were not always unambiguous. Moreover, the observation approach restricted access to the users' subjective perspectives, personal experiences, and the individual purposes of their visits to the green space. Questions also arise regarding the generalizability of the collected data to a broader population. Akremi argues that, particularly in applied research, it is often sufficient to comprehensively assess the studied case in order to determine whether the current state corresponds to the intended state (2022, 420f). The primary aim of this study was therefore to portray the actual usage patterns - current state - of the green space. Nonetheless, the findings cannot be extrapolated to represent the behavior of an entire target population. Additionally, it must be acknowledged that the mere presence of a researcher in the field could have been perceived as disruptive by some users, potentially influencing their natural behaviors.

8. Conclusion

The observational data collected indicate that the intensity of actual use within the study area can be characterized as spontaneous, occasional to moderate usage primarily by local residents. The green space was mainly frequented by walkers and dog owners, who used the area for brief periods, either as a pathway or for dog walking. In contrast, essential green space functions such as recreation, nature experiences, or social encounters/interactions were hardly observed. Furthermore, the proportion of children and seniors that were seen using the area was significantly lower than that of adolescents and adults. Based on observed interaction patterns, it became evident that users rarely engaged with one another during their time in the green space, nor did they appear to make visits together.

The key findings regarding the actual use of the study area provide insights into the quality of the green space and potential needs of the local residents. Considering that some of the valuable and diverse functions typically associated with nearby urban green spaces were not present among the observed activities and interactions, it can be assumed that the qualities of this green space do not fully meet the residents' needs, or that the space is perceived as unattractive for such uses. As a result of this moderate usage, residents of the Wohlers Eichen housing complex may be benefiting from the positive effects of green space functions only to a limited extent. This raises the question of environmental justice. A comprehensive concept of environmental justice not only considers the accessibility of green spaces in socially disadvantaged neighborhoods but also the quality of these spaces, and whether residents have equitable access to a healthy living environment (Böhme & Franke 2021, 71). Since the study area is an industrial brownfield site characterized by spontaneous urban wilderness, it was not developed through urban planning interventions tailored to the needs of Wohlers Eichen residents. As a result, the qualities of this space do not seem to correspond to the diverse demands of the local population, limiting the benefits that urban green spaces can offer.

In retrospect, the conducted observational study provided exploratory insights into the actual use of this green space. For this case study-based and intra-municipal analysis of the green area, the in-depth indicators of user behavior represented an effective extension of spatial monitoring (Rusche & Fina 2019, 217). A general picture of the intensity, as well as the predominant usage patterns and interactions, could be captured - insights that might not have been revealed through other empirical research methods (Münst 2004, 331). Nevertheless, due to certain limitations in the study's execution – such as the small sample size and the interpretation of the results from mere observation –, no factual conclusions could be drawn regarding the actual motivations, experiences, and wishes of the users of this green space. The results were largely based on assumed classifications of users into predefined categories, which means that the subjective perspective of the observing researcher may have influenced the findings. The insights gained about user behavior in the study area highlight the necessity of complementing and verifying these results with regard to the concrete needs of different target groups, e.g. by way of adding interviews to the observation. By combining multiple methods, more comprehensive knowledge could be generated, which may then be incorporated into urban planning processes and municipal actions in order to better utilize the untapped potential of this urban brownfield site.

In summary, it can be concluded that the methodological application of reflective observational studies – despite the limitations outlined – represents a valuable approach for collecting qualitative data on urban green space provision and user behavior. Due to the level of detail in data collection and the considerable methodological effort involved, this approach is particularly suitable for intra-municipal case studies (Rusche & Fina 2019, 217). Nevertheless, it is recommended that the results be deepened through interviews or surveys with local residents to better understand their practices and gather concrete insights into their ideas for redesigning the green space. Following the completion of the Oslebshausen Climate Forest Park, a comparative analysis could be carried out, contrasting the findings on the current utilization of the green space with observations of its use after the conversion into a Forest Park.

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Interreg North Sea

Co-funded by the European Union

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Series editor
artec Sustainability Research Center, July 2024