REGREEN
NATURE-BASED SOLUTIONS

Fostering nature-based solutions for smart, green and healthy urban transitions in Europe and China

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WP N°3 Mapping and Modelling of Ecosystem Services

Recommendations for Potential Target Values in Cities

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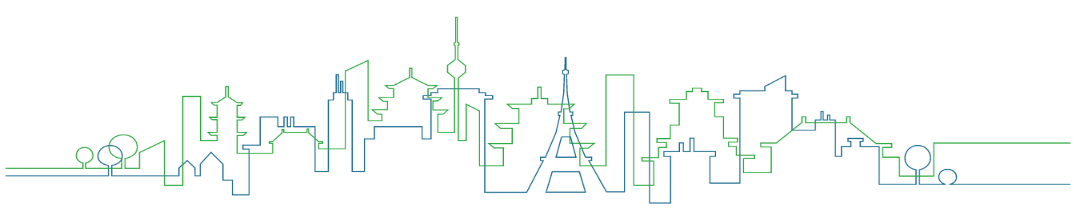

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EXECUTIVE SUMMARY

This document gives a wide array of target values on nature-based solutions (NBS). In the review, global institutions and their target thresholds for environmental pressures are discussed, as well as individual target values set by European frontrunner cities. It also pays tribute to the proposal by the European Commission for a regulation on nature restoration, for the first time setting concrete targets for increasing urban ecosystem areas. The adopted text by the European Parliament to require Member States to define satisfactory increasing trends at national level for urban green space and canopy cover instead of quantitative targets first proposed in the nature restoration proposal makes this report even more relevant. This deliverable delineates the gaps and needs to define environmental target values as standards throughout European cities. Therefore, the REGREEN project elaborates a typology of target values and illustrates synergies and dependencies between them. Furthermore, the barriers through silo thinking in governance are reflected. They may hinder achievement of NBS targets in cities. Major conclusions are drawn reflecting cross-sectoral insights from scientists, stakeholders and planners. Multiple benefits and trade-offs are discussed to deepen the knowledge of dependencies and synergies between types of targets. Policies demand recommendations and rely on findings like multifunctional benefits from NBS to underpin argumentation. Further interaction and transdisciplinary work must be undertaken to break down barriers and promote implementation of urban NBS. To do so, this document on recommendation of potential target values in cities may aid fostering this interaction.

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1 INTRODUCTION

1.1 Purpose of the document

The objective of this document is to elaborate the range of potential target values for various environmental pressures and related nature-based solutions (NBS) to reduce these pressures. The original document was announced as “Written summary of potential target values for cities”. The advancement of the project allows to go beyond summarising potential target values by not only giving an update on target values at international level and on the European Commission proposal to establish urgently required target values for NBS implementation in cities. As a unique selling point it discusses various targets that are central in the REGREEN European Urban Living Labs (ULLs – Paris Region, Aarhus Municipality and Grad Velika Gorica). From there the REGREEN collaborators pull together a synthesis on cross-sectoral potential target values and reflect barriers and constraints in achieving them.

This Deliverable is elaborated after a four-year-project run-time, and the project continues for another three months. This is a favourite position to include other project activities and tasks like the inclusion of review studies, understanding the ambitions of the ULLs, elaborating tailored scenario development, synthesising research across the ULLs and partnering researchers, shedding light to equity aspects for NBS, just to mention some. Well-fitting results from other deliverables find their way into this synthesis deliverable, underpin the specific targets by scoring local environmental pressures, and related NBS. Furthermore, prominent REGREEN articles contribute to the comprehensive report and witness the continuous collaboration across the partner institutes in REGREEN over time.

The consortium contributions are twofold: first, we share disciplinary knowledge by working out international reviews and the typology of target values for the REGREEN perspective across the ULLs. Then, we synthesise cross-sectoral target values in inter- and transdisciplinary collaboration. Here, especially the ULLs, their definition and priority setting of demanded ecosystem services and NBS implementation enrich the gained knowledge on synthesis, trade-offs and multiple benefits derived from target values. Through multi-perspective governance workshops at each EU ULL, also constraints and barriers could be identified that hinder, narrow down or delay planning and implementation towards attaining NBS target values.

1.2 Scope of the document

The core of the document is the REGREEN perspective on target values. In the conjoint findings targets can be thought of in different ways:

- Targets on environmental pressures (air pollution, water pollution, flooding etc.),
- Targets on the objects (the NBS),
- Targets on the level of ecosystem services provided by NBS; targets on equity (access and benefit distribution for different socio-demographic groups of residents in the city) and
- Targets on organisation.

To summarise, in this document the findings are not restricted to a certain degree of detail. Beyond giving a level of detail, the report points at a multi-level approach to capture the range and show the importance that target values have for towns and cities as lines of arguments to implement NBS.

As a background to the topic, Section 2 depicts the benefits from NBS against environmental pressures to foster resilience in cities. It introduces target values being beneficial for urban planning relating to the underlying ecosystem services that NBS generate.

Section 3 starts with a short review on internationally established target values including references for environmental pressures from EU-level and / or from other supra-national organisations. Here, globally acting institutions such as WHO set targets on environmental pressures across continents and countries. The implementation of both pressure and NBS implementation targets is on a different scale, from national level to the urban area. There are also NBS included implicitly by addressing at least part of the challenge. The short review on ambition levels of NBS implementation across European cities illustrates the advancements of frontrunner cities towards addressing target values. Furthermore, the proposal on nature restoration by the European commission including a summary table in the same section sheds light on meeting various NBS targets over time. There's still a risk of optimising for environmental pressures targets and compromising on other (multifunctional) aspects of NBS (e.g., trees are not just there for air pollution removal). Consequently, a quantified environmental pressure with an associated, quantified NBS might help decision makers to approach the topic.

In this deliverable the difference between scientific and political targets are made obvious and the confrontation between changing politics and research is contrasted. The suggested targeted types discussed in Sections 4 to 6 are not random, show the most central environmental triggers and have high consistency. The identified lack of capacity in the fields of governance and urban planning may lead to detriment outcomes. Yet, climate change and global warming put pressure on time horizons to define targets and implement related NBS. Current ambitions are clearly defined by the ULLs in several workshops. For this reason, the introduced ambitions are visualised in a table in Section 4 to mirror with the set target values and make them more tailored to individual urban needs. From a city perspective, there's advice required to find the best possible target that explains the needs for specific NBS. Section 5 emphasises that a target value should not just be a number; it must be richer to capture the multifunctionality of NBS. By profiting from the expertise aboard the REGREEN project, different dimensions are linked to focus more on the multifunctionality of NBS. In Section 6, the experiences from workshops are gathered to discuss shortcomings and barriers in governance to get clarity on where to start in the future to overcome obstacles.

1.3 Structure of the document

In Section 1, the topic of recommendations of target values is introduced, the scope of the document is delineated, and the Sections of the document are put in context to the complexity of the research. Section 2 points out the benefits from NBS for maintaining and increasing the resilience in cities. It gives insight into target values by informing on their mitigation of environmental pressures and discusses conflicts and barriers to attain target values in the global context. In Section 3, international reviews are referred to for target values on environmental pressures by global institutions. Established target values are presented from European frontrunner cities, and the latest proposal from the European Commission on nature restoration from 2022 is discussed. After having embedded the topic of recommendations for target values in cities in the international context, the specific REGREEN perspective is presented in Section 4. Here, the typology of targets is elaborated with rather disciplinary foci, such as ambition, ecosystem service, equity or organisational targets, to name the most relevant. This section shows the diversity and depth of the topic, before REGREEN reflects in Section 5 on cross-sectoral target values where the benefits are illustrated through synergies and dependencies of multiple targets. Section 6 discusses REGREEN findings from workshops on specific barriers in governance that may withdraw from attaining NBS targets. In Section 7 the concluding remarks may lead to new insights and give impulses for further research.

2 BENEFITS FROM TARGET VALUES

Targets values (e.g., for environmental pressures or for performance to avoid pressures) may consist of simple thresholds or ranges of values. We aim to go beyond this level and argue for each ULL and their specific situations (policies / climate embeddedness / prioritised pressures to be tackled / etc.) to identify the best fitting target values and tailored recommendations. We start from the present ecosystem service configuration of individual ULLs and aim for best fitting NBS in quality, quantity, spatial distribution. For this we need to define the appropriate spatio-temporal scales and reflect related scenarios.

2.1 Nature-based solutions (NBS) as an approach to urban resilience

This section first introduces how urban nature-based solutions (NBS) can serve as a tool to enhance resilience - what types of urban NBS contribute to addressing challenges related to climate resilience, including health and well-being. In doing so, it is significant to explore the ways in which resilience takes shape as the interaction of natural with social (social-ecological) systems. Is it about increasing the resilience of cities to environmental pressures or even about alternative ways of further developing urban futures? NBS play an important role in empirical studies. In the implementation of such solutions, trade-offs, conflicts and also disadvantages are to be expected, which in turn are a key issue for urban resilience to consider.

NBS has been adopted by policy makers at the EU level as an umbrella term for nature-based approaches, with the aim of contributing to solving societal challenges such as climate adaptation, disaster risk reduction and biodiversity loss. In particular, a city is considered resilient when NBS approaches also address social problems, environmental health, and the well-being of its citizens. In this respect, NBS occupy a central place in several EU policies and strategies, with the aim of minimizing negative environmental impacts.

The EU commission defines NBS as “Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions” (European Commission, 2023). The International Union for Conservation of Nature (IUCN) states that “Nature-based Solutions leverage nature and the power of healthy ecosystems to protect people, optimise infrastructure and safeguard a stable and biodiverse future” (International Union for Conservation of Nature, 2023), and the United Nations Environment Assembly (UNEA) describes NBS as “actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits”, and further states that nature-based solutions respect social and environmental safeguards (United Nations Environment Assembly, 2022). All three definitions point and NBS benefitting ecosystems and biodiversity, while also providing social, environmental and economic benefits and sustainable development.

2.1.1 Mitigation of environmental pressures through NBS for resilient cities

Although cities have a tremendous capacity to withstand, recover from crises, and often undergo profound changes to persist (Kuhlicke, 2018), they are also particularly vulnerable to climate change impacts and disasters given their morphology and sheer concentration of people.

By morphology, we mean how cities are typically built, that is, have impervious surfaces on roofs, streets, squares, and alleys. Historically, cities are also often located near bodies of water to enable trade, control strategic positions, and fishing. These locations include coasts, rivers, and wetlands. They have been modified over time by man-made interventions, building in floodplains, canalizing rivers, building dams that obstructed natural features.

The effects of climate change mean that extreme weather events are increasing sharply and affecting cities to a much greater extent. Due to the high degree of sealing (impermeable surfaces) in cities, this often leads to increased vulnerability. It relates to increased surface runoff with subsequent pluvial flooding during extreme rainfall events, and to river flooding due to the restriction of natural river flow and overflow areas on rivers and streams. During extreme heat events, the high degree of sealing contributes to high heating of the various sealed materials during the day and reduced cooling during the night. This urban heat island effect introduces a temperature difference that is at least 3-4 degrees Celsius higher than the surrounding area.

For these reasons, NBS are being sought, especially in urban areas, to respond appropriately and adaptively to the impacts of climate change and to minimize the risk of potential natural disasters. These NBS measures aim to make cities more robust and resilient. NBS also support a faster recovery impact from climate change impacts and natural disasters by working with and enhancing nature, restoring ecosystems, protecting them, and using their services, especially in cities, for human well-being.

NBS measures in particular help cities adapt to the impacts of climate change and slow further local warming, while providing a range of multiple environmental, social, and economic benefits. In the following two sections, we describe in more detail how urban NBS can support urban resilience. We then draw on examples of potentials, conflicts, and barriers to break down the role of NBS for a resilient city.

2.1.2 Urban NBS and how they support climate resilience

Key NBS options for resilient European cities include maintaining, restoring, and creating new parks and urban forests, planting urban trees, improving urban water management, and greening buildings. NBS are proving effective in combating high temperatures and flooding in cities and can simultaneously address multiple hazards and provide multiple benefits to the environment and to society (EEA, 2020). The scale of urban NBS ranges from individual small NBS on buildings or streets to large, systemic implementations of NBS in an urban area that are connected to areas near the city and the broader landscape (Banzhaf et al. 2022; Jones et al. 2022c).

Parks and urban forests

Among the different types of urban NBS, parks and urban forests as in Figure 1 are then recognised for their ability to reduce air and surface temperatures when adapted species are selected (Roy et al., 2012, Calfapietra, 2020, EEA, 2020). For example, grass surfaces exposed to sunlight can be up to 24°C cooler than concrete surfaces, and trees lower globe temperatures by 5-7°C due to shading and evapotranspiration (Armson et al., 2012). Urban parks are on average 0.94°C cooler during the day than built-up areas, with larger parks and those with trees having an even stronger cooling effect

(Bowler et al., 2010). In addition to mitigating the urban heat island effect and heat stress, urban parks and forests can also regulate stormwater, mitigating flood hazards by intercepting precipitation that subsequently evaporates, infiltrates the soil, or otherwise contributes delayed runoff (Berland et al., 2017). For example, while urban landscapes with 50-90% impervious cover lose 40-83% of precipitation to surface runoff, in a forested landscape this potential is typically about 13% of precipitation after similar rainfall events (Pataki et al., 2011).

Figure 1 Park Chalo Saint Mars, Paris Region. © Gwendoline Grandin, IPR.

Urban Trees

Trees and other woody vegetation along streets and in public plazas and parking lots can help reduce stormwater runoff during heavy rain events (see Figure 2). The structure in terms of number, density, size, and species composition, health, and spatial configuration of street trees largely determines their benefits over stormwater absorption. One study of street trees estimated that a tree can intercept 6.7 m^3 of water per year, which consequently reduces the frequency and severity of combined sewer overflow events (Berland and Hopton, 2014). These results are comparable to those of other studies (Berland et al., 2017). In the economic sense, this means that a study from Lisbon, for example, estimated an economic benefit of $47.80 (i.e., €44.20) per tree thanks to its ability to reduce stormwater runoff (Soares et al., 2011). Urban trees also help improve the microclimate by providing shade, lowering air temperature, reducing heat island effects, modifying the microclimate, and slowing wind speed, followed by reducing direct sunlight, relative humidity, glare, and reflection (Bowler et al., 2010, Roy et al., 2012, Calfapietra, 2020).

Figure 2 Tree avenue in Grad Velika Gorica. © Grad Velika Gorica Municipality

2.1.3 Nature-based solutions for urban water management

NBS for urban water management include stream restoration, so-called bioswales, and detention basins (or bioretention cells/filters), (constructed) wetlands, rain gardens, permeable sidewalks, riparian vegetation strips, and green roofs. Unsealing asphalt and concrete in private and public urban spaces provides further opportunities to implement many such NBS, including reopening channelised waterways (*Rivers to light* program) and restoring riverbanks. Flowing freshwater also contributes to the cooling effects of cities and provides habitat for wildlife species (e.g., birds, fish). For urban water management, NBS aim to control surface runoff volumes and timing, thereby reducing the risk of flooding during heavy rain events (Vojinovic, 2020). This approach is largely in contrast to traditional grey infrastructure in built-up areas, which often directs runoff into the wastewater system, causing flooding during extreme precipitation events. Also, discharging wastewater into streams and rivers exacerbates hydrologic disturbances and stresses ecosystem structure and function through pollutant inputs (Roy et al., 2008). By combining NBS with sewer infrastructure, bioswales as in Figure 3, street trees, and rain gardens can intercept, evaporate, and infiltrate stormwater before it reaches sewer systems, reducing the volume of water that needs to be treated (Wild, 2020). The effectiveness of NBS for municipal water management depends on the type and design of each NBS and local conditions (Miller et al. 2023). Small NBS have been found to reduce runoff by 30-65% for porous sidewalks, up to 100% for rain gardens, or up to 56% for infiltration trenches (Ruangpan et al., 2020).

Figure 3 "Bioswale" in Aarhus Municipality, © Aarhus Municipality

2.1.4 Greening of building envelopes

Densely populated urban areas have high land use competition. Here, greening the building envelope (e.g., green roofs, green walls, or façades, see Figure 4) provides effective local benefits for small-scale climate adaptation and offers some reduction in exposure to natural hazards related to water and thermal management. Especially in terms of water management, green roofs can store larger amounts of water than conventional roofs and delay water runoff (Oberndorfer et al., 2007, Pataki et al., 2011). A heavy rain event of short duration (e.g., 30 min) can even be completely retained by a dry green roof (Richter and Dickhaut, 2018) and generally reduce the discharge volume by up to 70% and the peak flow volume from the green roof by up to 96% (Ruangpan et al., 2020). In terms of thermal management, green roofs are effective in lowering air temperature, improving indoor thermal comfort, and reducing energy demand (EEA, 2020). For example, green roofs and façades have been found to reduce the energy required for air conditioning by up to 40-60% in a Mediterranean climate (Alexandri and Jones, 2007, Mazzali et al., 2012) and surrounding streets can cool between 0.03°C and 3°C (Francis and Jensen, 2017). In addition, green surfaces, whether on buildings or on the ground, have a higher albedo (20-30%) than artificial hard surfaces (5%), which helps reduce the urban heat island effect by reflecting more light (Perini and Rosasco, 2013). Although installing, maintaining, and disposing of green roof systems may seem costly at first glance, the cost is small compared to total construction costs (0.4% of total construction costs for multi-story residential buildings), and the life-cycle costs over 40 years are like those of black roofs (Dickhaut et al., 2017).

Figure 4 Left: Semi-intensively managed green roof, Paris Region. © Grooves project 2017-2019, IPR. Right: "Low-tech" green wall, Paris Region. © Marc Barra, ARB IDF.

2.1.5 NBS against health hazards from heat and noise

The effectiveness of NBS to provide ecosystem services, and as described above, effectively reduce urban heat island effect, noise, and air pollution, has positive health impacts (van den Bosch and Ode Sang, 2017). The strongest evidence here is the reduction in health hazards from heat (Basagaña et al., 2011, Heaviside et al., 2017). High temperatures aggravate existing diseases and disease processes, such as respiratory diseases, and limited thermoregulation, especially in the elderly, can have a direct impact on cardiovascular systems. (D'Ippoliti et al., 2010).

There is also evidence that NBS can reduce negative perceptions due to noise (Dzhambov and Dimitrova, 2014), and reduce noise levels from e.g. road traffic (Fletcher et al. 2022). Noise reduction from NBS can have a positive effect on sleep disturbances and heart conditions. A meta-analysis found a clear inverse relationship between exposure to green space and all-cause mortality (Rojas-Rueda et al., 2019).

2.1.6 NBS for clean air

The usefulness of NBS for cleaning air is very complex. Basically, meadows, shrubs and especially trees provide a large surface area for fine dust depositing from the air more effectively than other surfaces (McDonald et al., 2007, Przybysz et al., 2021, Popek et al., 2022). Trees provide the largest surface area, and so are by far the most effective vegetation type at removing fine particulate matter (Nemitz et al. 2020; Jones et al. 2019). On smooth or unplanted surfaces, particles can be stirred up again by wind. Converting fallow land to green space can thus help reduce air pollution. Larger green spaces can also help mix polluted air.

When planning NBS, it is important to note that different tree species are differently effective at reducing air pollution (Zafra-Mejía et al., 2021) and that, for example in narrow street canyons, the local aerodynamic conditions can lead to pollution trapping, and therefore influence the choice of NBS (Pugh et al., 2012). Well-designed use of NBS can reduce air pollution in vulnerable urban areas (Sæbø et al., 2012).

2.1.7 NBS for exercise and stress reduction

Other health functions of NBS are often cited as building capacity (e.g., getting more exercise in citizens' daily lives) and restoring that capacity (their well-being) (Dzhambov et al., 2019). Green spaces in cities provide citizens with opportunities for exercise and sport in parks, traffic-calmed streets and neighbourhoods, or community gardens. Studies here show, for example, that citizens who regularly visit city parks get more exercise and tend to be less overweight, and that citizens who live farther away from city parks are generally less active in sports (Kaczynski and Henderson, 2007, Coombes et al., 2010, Pietilä et al., 2015). However, these studies are not consistent (Kaczynski and Henderson, 2007, Lachowycz and Jones, 2011), and additional factors play an important role, such as what activities are undertaken, personal motivation, age, gender, and health status (and dog ownership), as well as socioeconomic factors, as wealthier neighbourhoods often have better access to better-maintained green spaces (Bauman et al., 2012).

Closely related to this are positive effects on mental health (van den Berg et al., 2015), stress, emotions and attention (McMahan and Estes, 2015, Bijnens et al., 2022). Sufficient access to nature experiences help build resilience for citizens, or at least a buffer against stressful city life, although health benefits can also come from visual stimulation, views of nature (or even virtual nature impressions) - experience (Jo et al., 2019). For this, there is little evidence in experimental studies of physiological mechanisms such as reduction of cortisol or blood pressure, but a clear link between nature experience and affect (McMahan and Estes, 2015) as well as emotions such as anger and sadness (Bowler et al., 2010).

2.1.8 NBS for social well-being

Urban NBS approaches can directly and indirectly address the well-being and health of citizens and strengthen social resilience. Research here refers to impacts of diverse landscapes or approaches such as urban (public) green spaces, parks, or street trees, and their characteristics such as density, species composition, quality, aesthetics, and basic physiological and psycho-social mechanisms for health and well-being (van den Bosch and Ode Sang, 2017, Markevych et al., 2017).

NBS can also play an important role in the social well-being and quality of life of citizens. Community-designed and used public open spaces such as parks and gardens can create cultural experiences, social networks, social capital, and a strong sense of community, and have positive impacts on safety and crime (perceived and actual reductions in crime, for example, when unused open spaces are developed through NBS) (Francis et al., 2012, Hunter et al., 2019). Studies also indicate that access to nature can promote pro-social behaviours such as sharing, helping, and cooperating in children and adolescents (Putra et al., 2020). Social well-being also includes spiritual experience of nature, even in urban parks that provide opportunities for meditation, reflection, meaningfulness, and connection with self and nature (Baur, 2018). As noted above, access, aesthetics and quality are important here.

2.2 Conflicts and barriers to attain NBS related targets

2.2.1 Potential conflicts against achieving environmental targets

Urban green spaces, despite their potential to positively impact social cohesion, may in turn also contribute to worsening social inequality, as NBS tend to be created in wealthier neighbourhoods and receive more long-term funding for maintenance there. Urban green spaces are often differentially used by different groups of citizens and can be exclusionary (Stodolska et al., 2011). Conversely, when NBS are developed in traditionally less financially supported neighbourhoods, green gentrification can be an important unintended consequence. Studies on this are still limited but suggest increasing marginalisation of citizens in these neighbourhoods and reduction of sense of community and belonging (Jelks et al., 2021). NBS such as parks, community gardens, and street trees also have social conflict potential between different groups of citizens (e.g., youth, dog owners) and their different uses of green spaces (Harris et al. 2019).

Participatory and co-creation processes are often driven as a prerequisite for successful NBS implementation on the ground (Nunes et al., 2021). In practice, however, they can present difficulties for municipalities in managing the expectations of the public.

2.2.2 Potential barriers against implementing NBS

NBS is multifunctional and therefore offers a wide range of benefits in urban environments, helping to address challenges ranging from climate adaptation to social inclusion to health improvements. However, such multifunctionality requires an interdisciplinary approach and collaboration across traditional sector silos such as health, planning, climate, and parks departments; or at the policy agenda level between climate, biodiversity, and economic development (Grunewald et al. 2021). Fragmented and isolated governance arrangements within a community, or lack of coherence between policies at all levels of governance, can impede collaboration, synergy, and joint funding across multiple agendas, creating a barrier to NBS implementation (Pappalardo and La Rosa, 2020, Kirsop-Taylor et al., 2021).

Although the notion of NBS and the overall potential of NBS to improve urban resilience in Europe's cities is spreading through policy developments and extensive investment by the European Commission in advancing the NBS agenda through the Horizon 2020 and Horizon Europe research programs, there is still a pronounced lack of awareness at the policy and technical levels. This is underpinned by the widespread lack of specific evidence on the ground about the impact that different types of NBS can offer, at what scale, combination and quality of design and management.

3 INTERNATIONAL TARGET VALUES – A SHORT REVIEW

3.1 Pressure targets at global level

To estimate how severe environmental pressures are for cities, it is important to understand at which range they may cause damage or do harm to people and the environment. On the one hand, narratives allow to capture the extent of the damage done and the suffering of the people. On the other hand, it seems essential to record and evaluate the degree of an environmental pressure. To do so, global or continental standards help to classify a situation as extreme, high, average, or low pressure. For this reason, frequently recurring environmental stressors such as heat, noise, air pollution and flooding are listed in Table 1 including their related target values, ranges and thresholds. Beyond these global actors who define these minimum / maximum values, there are many more references pointing at this topic. For the study on recommendation for target values in REGREEN this Table 1 serves as background knowledge in which to embed own findings. They will be discussed in great detail in Section 4.

Table 1 International references on environmental pressures

Environmental pressures	Target values from international references	Defined target values, ranges and thresholds
Heat stress	EEA (Crespi et al. 2020)	Heat days: no. of hot days per year with air temperature ≥ 30 °C Tropical nights: daily minimum temperature exceeding 20 °C
Noise	WHO (World Health Organisation, 2018)	Road Traffic: Average noise exposure 53 dB(Lden); night-time, 45 dB(Lnight) Railway: Average noise exposure 54 dB(Lden); night-time, 44 dB(Lnight) Aircraft: Average noise exposure 45 dB(Lden); night-time, 40 dB(Lnight) Wind Turbines: Average noise exposure 45 dB(Lden)
Air pollution	WHO (World Health Organisation, 2021)	Annual: PM2.5 < 5 µg/m³ 24 hours: PM2.5 < 15 µg/m³
	EU (European Union, 2008)	Annual: PM2.5 < 20 µg/m³
Flooding	UK Government planning policy statement PPS25 (Government of the United Kingdom2010)	No standard development in zone 3a, i.e. high probability of flooding - Definition: this zone comprises land assessed as having a 1% or greater annual probability of river flooding or a 0.5% or greater annual probability of flooding from the sea in any year. The functional floodplain as flood zone 3b, i.e. only the water-compatible uses and the essential infrastructure suitable here - Definition: this zone would flood with an annual probability of 5% or greater in any year, or is designed to flood in an extreme flood event (probability 0.1%).
	European Union Directives, including the Water Framework Directive (European Parliament, Council of the European Union, 2000) and Floods Directive (European Parliament, Council of the European Union, 2007)	The EU Directives require consolidated river basin management planning, assessment and mapping of hazards and risks, and preparation and use of flood risk management plans.
Water quality	Water Framework Directive (European Parliament, Council of the European Union, 2000) (member states have specific standards for implementation)	Chl-a: 90th percentile < 0.01 mg/L
Lack of access to green spaces	UN SDGs (United Nations, 2015)	Provide universal access to safe and inclusive green spaces
	WHO (World Health Organisation, 2017)	Access to public urban green spaces within 300 m of at least 0.5 ha

3.2 Ambition targets in European cities

With cities globally addressing the sustainable development goals (SDGs) and taking action to adapt to climate change, regreening and using NBS is one strategy often brought up in planning and policy documents. With regards to how regreening is supposed to take place, this varies and follows different type of strategies. These include for instance:

- Enhancing and improving existing green spaces. In many cities the improvement of quality is often brought up, with limited specification and definition of what those qualities are, and hence there are limitations on how this could be followed up through monitoring to evaluate the success of the action. There are also examples of specific qualities that are either increased or decreased, such as management of exotic and invasive species, provisions of public use, poster and signage. Enhancing the use and function are another approach to improving existing green spaces;
- Accessibility. With regards to improving the use of green space by the population, access is often seen as a key factor, and with ambitions to increase accessibility often expressed, though less specific with regards to group of people and type of green space;
- Increasing amount/area of green space. Several cities are expressing their ambitions with regards to regreening through specifying an increase in different type of green infrastructure. Examples found are for instance to increase the area of areas with permeable soils in city, creation of new green spaces, development of smaller forms of green infrastructure, temporary greening actions of vacant development sites, planting of trees, establishment of riparian vegetation.

While ambitions are found for most of the cities covered in this review of planning and policy documents of European cities, the presence of measurable targets are fewer. Most of the ambitions could however still be monitored. These are either expressed as an amount to increase with or as a specific target number to be reached, as could be seen in Table 2. The table shows that there are some targets found with regards to the improvement of qualities in relation to improvement of existing green infrastructure. This includes target for noise level (less than 50 dB(A) in green spaces), the minimum amount of experience qualities found in green spaces found depending on size, minimum quality standards expected by local council managed green spaces and specifications for ecological quality (minimum amount of dead wood and ecological qualities of trees).

With regards to specified targets for improving accessibility, these are more and also wider spread. There are different targets with regards to minimum distance people should have to a green space, ranging from 50 m to 300 m. There are also cities that expand on this by specifying distance to closest green space for schools (300 m specified by Helsingborg, Sweden) and presenting a variation of distances to different sizes of green spaces or with certain qualities.

Most targets are found for increasing green in the city, with a wide variation in type of measurement. Several cities present ambitious targets when it comes to increasing the amount of trees with cities having signed up to the 1 million tree challenge (Belfast, Manchester, Edinburgh) or expressed as trees to be planted ranging from 10,000 (Strasbourg) to 500,000 trees in 5 years (Munich). For some of the cities there are also targets with regards to type of trees to be planted, for instance through planting of native species (Alcalá, Madrid). In Barcelona this is specified as 40 % of species should be adapted to global change and no species should represent more than 15% of the total amount of trees. For tree canopy cover, several cities (Barcelona, Malmö, Manchester, and Nantes) have already included the 30% coverage suggested by Konijnendijk (2021) while other numbers mentioned include 20% (Newcastle) and an increase by 5% (The Hague). There are also targets identified for increasing woodland coverage, amount of wildflower meadows, amount of general green space. Some cities are specifying the amount of green space that should be available per person (10 m^2 park and nature in Helsingborg) or per household (75 m^2 public green space in Utrecht). For Madrid and Manchester, there are targets with regards to nature reserve/biodiverse areas.

Table 2 Specific target values at city level

Ambition	Target types found for the ambition	Numeric values
Improving existing green infrastructure	Noise level in GS	Less than 50 dB(A) in parks and nature areas and 45 dB(A) in recreational areas (Helsingborg)
	Availability of experiences/qualities in GS	Small areas should have 3-4 experience qualities, medium sized 5-6 experience quality and large nature and cultural landscape preferably 8-9 experience qualities. All council managed large green space should be of 'good' quality for City Parks, Community Parks and Recreation Grounds and 'good+' for Premier Parks and Natural Heritage Parks (Edinburg)
	Ecological quality	75 % of the number of urban trees will be ecologically appropriate 4*, 3* or 2 (The Hague) Forest should include 20 m² dead wood and at least 3 high stumps per hectare (Helsingborg)
Improving accessibility	Distances/accessibility to green space generally	50 m (Växjö) 300 m (Malmö) 200 m (Stockholm) 25 m² of green within 300 m (Turin) 6 m²/inhabitant within 500 m (Berlin)
	Park and nature within distance to school	300 m walking distance (Helsingborg)
	Walking distance to large green space (min. 2 ha)	800 m (Edinburgh)
	Access to areas with play quality	1 m²/inhabitant within 500 m (Berlin) Houses and flats have access to 800 m walking distance to good quality or 1200 m walking distance to very good quality or 2000 m direct distance to excellent quality (Edinburgh)
	Access to good quality accessible green space of at least 500 m²	Within 400 m walking distance (Edinburgh)
	Access to green area larger than 1 ha	Within 300 m walking distance (Essen, Helsingborg, Växjö)
	Access to area larger than 10 ha	Within 500- 800 m (Växjö)
	Access to nature or culture landscape of at least 100 ha	Within 2500 m (Växjö)
Increase amount/area of green elements	Amount of trees	1 million trees (Belfast, Manchester, Edinburgh) 10,000 trees to be planted (Strasbourg) 50,000 trees to be planted (Nantes) 100,000 trees (City of Lyon, Porto) 1000 per year (Leipzig) 500'000 trees in 5 years (München)
	Tree species suitability	Increase plant diversity by planting 2740 trees and 12,660 shrubs of more than 25 native species (10 shrub species, 3 climbing species, 12 tree species) (Alcalá) 40 % of tree species are adapted to global change (Barcelona) No species of trees represents more than 15 % of the total (Barcelona). Planting of 540,000 native trees/shrubs (Madrid)
	Tree canopy cover	30 % (Malmö, Manchester, Nantes) 20 % (Newcastle) 35 % (Barcelona) Increase by 5 % (The Hague)
	Woodland cover	20 % (Edinburgh)

Ambition	Target types found for the ambition	Numeric values
		100 ha planted (Nantes)
	Amount of wildflower meadows	Increase by 10 % (Edinburgh)
	Amount of general green	40 % green in every neighbourhood (Utrecht) 10 ha/year of new public green space (Munich)
	Amount of green space per capita	10 m² park and nature per person (Helsingborg) 75 m² public green space per household (Utrecht)
	Amount of green roofs	1000 green roofs (Berlin)
	Nature Reserves/Biodiverse areas	1 hectare per 1000 residents (Manchester) 25 new areas (Madrid)
	Change asphalt to green	7 ha (Nantes)

Table 2 is based on a review of municipality documents identified through their homepages. These documents include plans and policies related to green structure, climate change adaptation and Agenda 2030 as well as comprehensive plans. For each city, the documents were reviewed by a person fluent in the language and later translated to English. The following cities were included in the review: Belgium: Brussels, Leuven; France: Nantes, Strasbourg, Lyon; Germany: Berlin, Dortmund, Essen, Freiburg i.Br., Leipzig, München; Greece: Athens, Thessaloniki; Ireland: Dundalk; Italy: Turin, Bari, Milan; The Netherlands: Eindhoven, Utrecht, The Hague; Poland: Gdansk, Katowice, Krakow, Wroclaw; Portugal: Lisbon, Porto; Spain: Alcalá, Barcelona, Grannollers, Madrid, Valencia; Sweden: Malmö, Helsingborg, Stockholm, Växjö, Umeå; UK: Belfast, Edinburgh, Manchester, Newcastle.

3.3 The proposal on nature restoration by the European Commission

Nature restoration has become an essential task in Europe for which reason the European Commission elaborated a proposal for a Regulation on nature ecosystems amongst which are also urban ecosystems. Article 6 of the European Commission's recent Nature Restoration Proposal (European Commission, 2022a) suggested concrete targets for cities, towns, and suburbs in Europe to ensure that there is no net loss of nature, and that the area of green urban spaces is increased. The amendment adopted by the European Parliament on 12. July 2023 on the Nature Restoration Proposal (European Parliament, 2023) maintains the requirement of no net loss by 2030 in the total national area of urban green space and of urban tree canopy cover in urban ecosystems but removes concrete targets of increasing the area of green urban space. Instead, the adopted text requires achieving an 'increasing trend' after 2030 until a 'satisfactory level' is reached. The satisfactory level should be determined by each EU Member State.

Currently, cities, towns and suburbs represent 21.5% of the EU territory (European Commission, 2022b) and are growing. Over the last 20 years, the urban artificial surface has increased by an average of 3.4% per decade from 2000 to 2018 (European Commission, 2022b). Cities are also densifying within city boundaries with an average loss of urban green space and tree canopy cover by 0.1% per year (MAES report cited in European Commission, 2022b).

To restore urban ecosystems, the Commission proposed targets in the proposal for a regulation on nature restoration for the first time to all cities and suburbs in Europe the following:

- halt the net loss of urban green space and urban tree canopy cover by 2030 compared to 2021;
- increase total national urban green cover by at least 3% of the total area of cities and suburbs by 2040 and by at least 5% by 2050 compared to 2021 levels;

- achieve coverage of at least 10% urban tree canopy by 2050 compared to 2021; and
- ensure a net gain in urban green space integrated with existing and new buildings and infrastructure developments.

Table 3 outlines the areas needed across the EU for urban ecosystems if these targets were to be adopted:

Table 3 Areas needed to meet the proposed respective targets for 2030, 2040 and 2050 by the European Commission (European Commission, 2022b)

Targets	Area (km^2)	Area (% of LAUs)
Urban green for no-net-loss by 2030	2900	3.00
Urban green for 2040 target	26,679	2.00
Urban green for 2050 target	17,786	5.00
Total additional urban green	**44,465**	**5.00**
Tree cover for no-net-loss by 2030	2059	
Tree cover for 2040 target	19,176	2.15
Tree cover for 2050 target	12,784	1.43
Total additional tree cover	**31,959**	**3.58**
Tree cover for 2050 target of 10% in cities, towns and suburbs	9522	1.06

Note: LAUs= Lower Administrative Units. Core cities normally correspond to LAUs.

The European Commission's Communication on Climate Change Adaptation from 2021 also emphasizes the need for and benefits of leveraging the effectiveness of NBS to adapt to climate change through the development of urban green spaces and the installation of green roofs and walls, but without setting specific NBS targets (European Commission, 2022b).

The adopted text of the European Parliament on 12 July 2023 on the proposal for a regulation on nature restoration still requires Member States to ensure no net loss of total national area of urban green space and urban canopy cover by 2030. After 2030, however, the adopted proposal requires Member States to define a national 'satisfactory level' of increased urban green space, including into buildings, infrastructure and urban ecosystem areas. The increasing trend unto the yet-to-be-determined-target-levels in each Member State should be monitored every six years until the target level would be achieved.

4 TYPOLOGY OF TARGET VALUES FOR EUROPEAN CITIES FROM A REGREEN PERSPECTIVE

The relatively new concept of NBS builds on ecosystem services (ES) frameworks (Bolund and Hunhammar, 1999, ILO et al., 2022). They can be used to identify thematic areas, which can then in turn be linked to NBS in catalogues of requirements for urban areas. However, if this concept is given a general validity, it may lead to the fact that individual cities do not easily recognise how they could optimally use these NBS approaches for their situation. For this reason, it is important to tailor the approach to environmental pressures and related urban needs. In REGREEN, three such showcases, the three European Urban Living Labs, are presented to discuss the most prominent target types that are considered significant for urban NBS implementation.

4.1 The three REGREEN Urban Living Labs (ULLs) as study areas

The cities in the EU funded project REGREEN differ significantly in these specific challenges as well as by their population numbers and geographical extent (see Figure 5). The smallest Urban Living Lab (ULL) is the city of Grad Velika Gorica, south of Zagreb in Zagreb County. It has an area of 328 km² and 60,000 inhabitants. As the second largest city in Denmark, Aarhus Municipality is represented in the project with 468 km² and 341,000 inhabitants. As the largest ULL, Paris Metropolitan Area, also named Paris Region, covers the entire Department of Île de France, with 12,213 km² and 12,000,000 inhabitants.

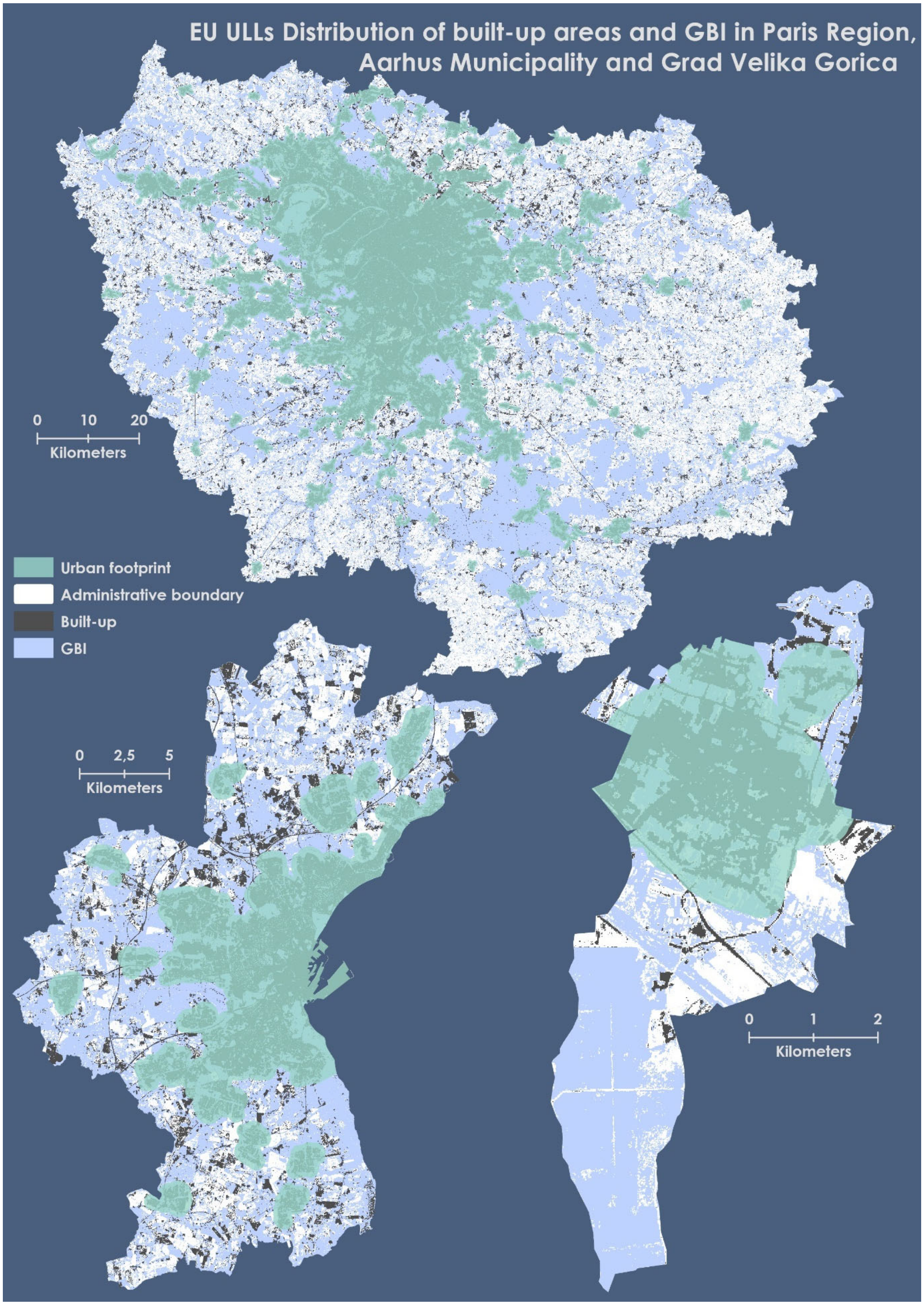

Figure 5 The EU ULLs in REGREEN: their administrative boundaries and urban footprints, as well as the distribution of built-up areas and green-blue infrastructure (GBI)

Within the project, a framework is created to apply different methods transferable to the three cities. Many of the problems identified by the cities fall into two categories. On the one hand, coarse-scale problems such as air quality are named as drivers, but also problems that have to be solved in a geographically smaller reference area, in particular the urban heat island effect, access to green spaces and the prevention of pluvial flooding.

The heterogeneity of land cover and land use in cities as well as the exact identification of hotspots requires on the one hand the work with high-resolution spatial data and creates on the other hand a strong neighbourhood reference.

For example, the catchment and impact area of urban green spaces is locally limited, depending on the ecosystem service, which is also exemplified in Figure 6. The Euclidean distance assumes a straight line between two points (e.g., home and park), along which the distance is measured. In contrast, the network analysis approach uses the distances along paths, streets, alleys, etc., computing the shortest distances (e.g., between home and park). Depending on the density of the public infrastructure, residents may or may not benefit from a nearby park with regards to shortest walking/cycling distances.

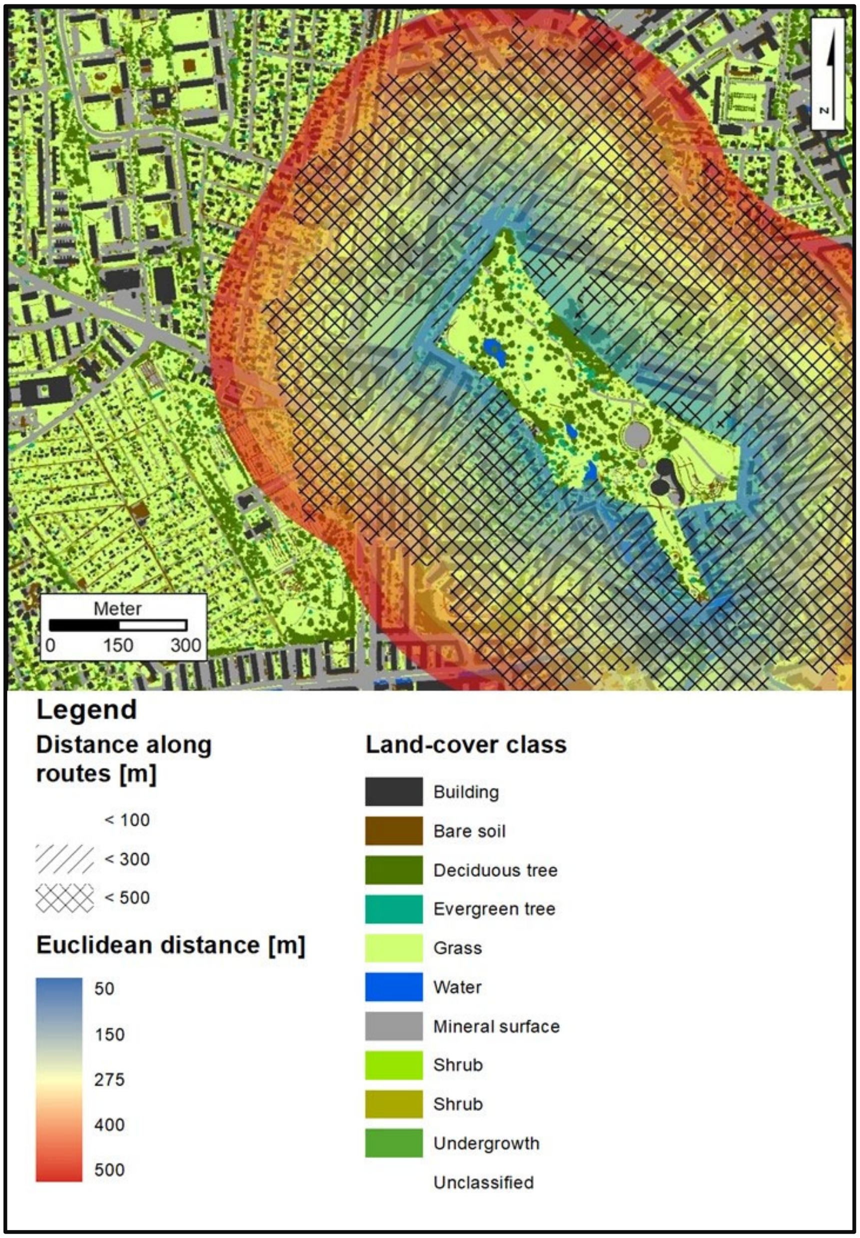

Figure 6 Access to nearest green space by actual walking and Euclidean distances

Effects of NBS such as air temperature reduction is primarily measurable in or immediately adjacent to areas of urban green space, and the various city guidelines for access to green space provide a further boundary to the space.

4.1.1 Potential targets driven by policy development

Within the REGREEN project ULLs, an example of targets being driven by regional policy development is the new Regional Master Plan in the Paris Region (Schéma directeur de la région Île-de-France environnemental, 2023). It identifies development trends up to 2040. The new master plan has as one of its main objectives to ensure that no net land is absorbed in the region. This necessarily means compensatory measures and the de-paving and renaturation of existing urban sealed areas. The region has also announced its intention to promote ecological restoration, renaturalisation and ecosystem protection projects as part of the regional climate adaptation plan launched in 2021 (Schéma directeur de la région Île-de-France environnemental, 2023).

Figure 7 illustrates environmental risks to health and well-being and Figure 8 indicates potential sites for mitigating environmental risks. This is based on a methodology developed by IPR in REGREEN D3.2[3].

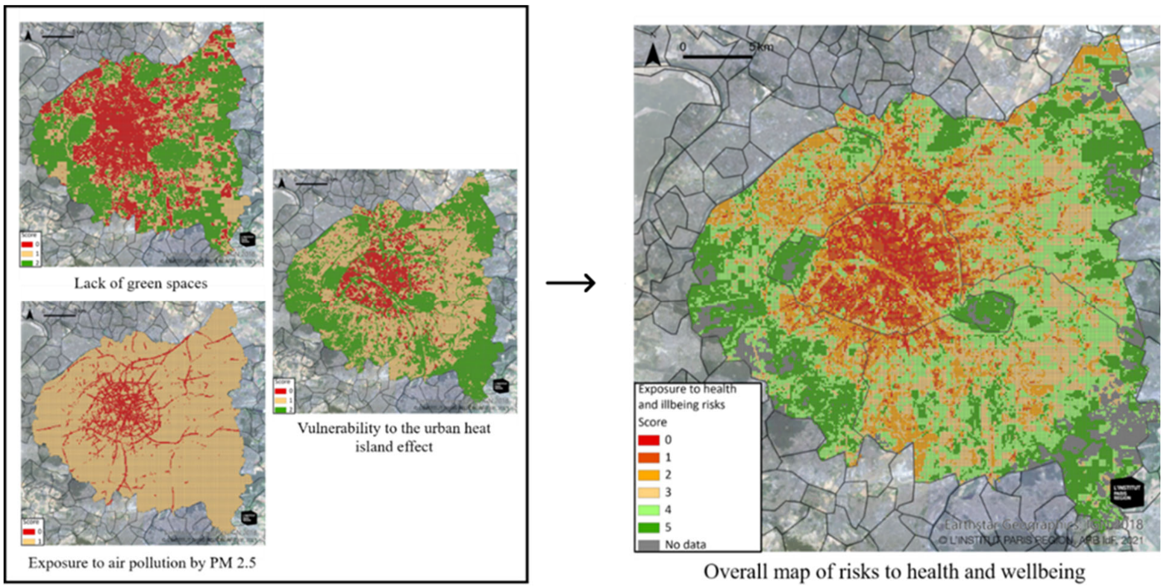

Figure 7 Illustration of environmental risks to health and well-being

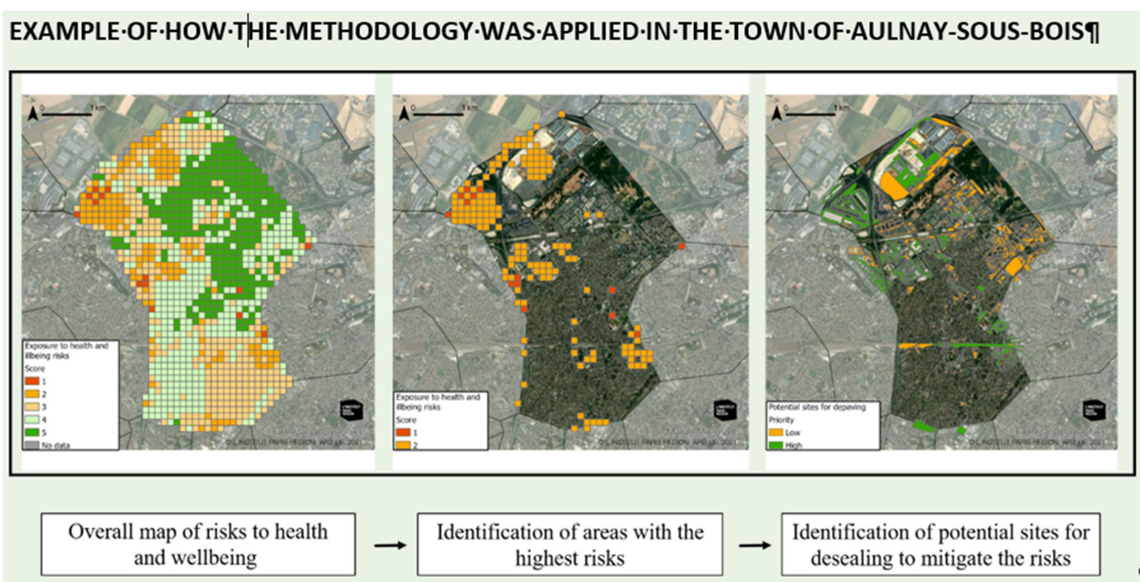

Figure 8 Elaborating potential sites for mitigating environmental risks

In the municipality of Aarhus, Denmark, a climate adaptation strategy has been developed to plan with, rather than against, water flows to minimise the risk of damage and costs associated with

3 https://www.regreen-project.eu/wp-content/uploads/REGREEN-D3.2-Guidelines-for-depaving-and-re-greening-strategy-in-cities-2.pdf

flooding (Aarhus Municipality, 2020), using NBS and hybrid NBS for water management to provide more water space inside and outside the city. This takes advantage of the multiple functions and benefits of using NBS for climate change adaptation (see Figure 9). Added values, including improved opportunities for healthy and interesting outdoor living, enhancing biodiversity, improving social communities, health, and well-being, are realised through the creation of new natural areas, improving the quality of nature in existing natural areas, implementing new attractive urban green spaces, regenerating neighbourhoods, and connecting the city and surrounding hinterlands with trails and waterways.

Planning tools such as 30-meter no-built zones around waterways and green standards for new urban developments contribute to this effort.

Specific 2030 goals under the Climate Adaptation Strategy and Greener Community Policy Aarhus Municipality (2020) include:

- Doubling the zones with protected areas and forest in the municipality from 2000 ha to 4000 ha;
- 80 % of natural areas owned by the municipality in good to high natural quality. For the whole municipality, 40 % of all natural areas should be in good to high natural quality;
- 25 % of natural areas - 1000 ha - managed with rewilding techniques and year-round grazing;
- 800 ha of forest managed for biodiversity, and not as a production forest;
- Restoring and reversing watercourses and protecting selected watersheds from urban development; and
- 10,000 new urban trees by 2025.

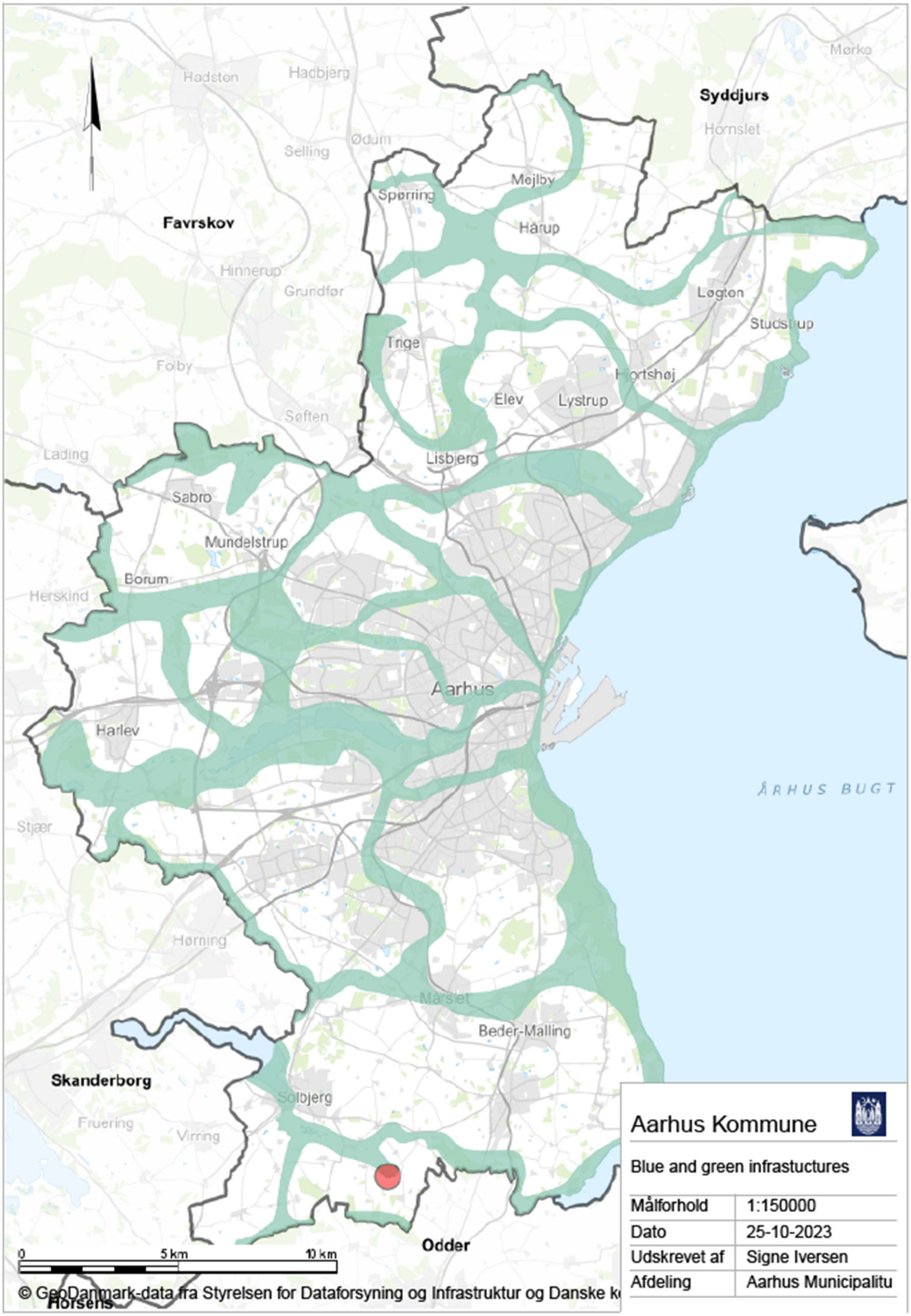

Figure 9 Green-blue infrastructure planning in Aarhus Municipality (Aarhus Municipality 2023)

4.2 Ambition targets - implementing multiple NBS types

To facilitate the work with the ULLs, representatives from each were interviewed separately to better understand their different foci. The collected data contained information on object types, such as parks and wetlands, with different categories for pocket parks, botanical gardens, ponds and rivers. For each of those, the targets set by the ULLs were collated, with more information provided on overall and minimum target, policy context and funding amongst others.

By comparing the ambitions of the three European ULLs, certain patterns emerge as seen in Table 4. All the three are set to increase the number of parks in general, as well as the amount of street trees. Equal thought is given to blue infrastructure, with each ULL committed to construct, restore and protect new and existing wetland features. In addition, all three European ULLs are looking into the potential of green roofs, by conducting feasibility studies.

Overall, the policy context usually points to EU directives, which are locally adapted, with timeframes set to 2030.

Outside of overlapping commitments, Aarhus Municipality and Paris Region are additionally set to improve and increase the areas dedicated to urban forests, as well as urban farming.

Table 4 Ambitions for implementing multiple NBS types across EU ULLs

Ambition / ULL	Push for new parks	Push for new street trees	Wetland construction, renaturalisation protection	Water ways renaturalisation and protection	Increase urban farming	Establish urban forest	Green roof potential assessed
Aarhus Municipality	☑	☑	☑	☑	☑	☑	☑
Paris Region	☑	☑	☑	☑	☑	☑	☑
Grad Velika Gorica	☑	☑	☑	☑	☒	☒	☒

Apart from the more overarching goals, each ULL has identified specific goals for fostering green and healthy urban transitions.

The goals in Grad Velika Gorica encompass more than just the rehabilitation and revitalisation of wetlands and rivers spanning a 2-kilometre stretch. They also involve the creation of a bicycle lane that connects to canal initiatives. This is linked to the overall goal of raising awareness for NBS in Grad Velika Gorica. Public spaces have been under pressure, as there is a demand for more parking spaces, leading to the closing of green spaces. In addition, the remaining public spaces tend to feature less vegetation than desired. As a result, the city's urban planning department is in dialogue with its department for municipal green infrastructure. The municipality also investigated to establish more green roofs in combination with solar panels and has identified a possible site.

Aarhus Municipality ULL in contrast is more focused on creating new parks. One set of ambitions is to establish three to four new parks within the next ten years, along with 20 to 30 new green areas, also featuring new recreational trails. Transportation networks are also under consideration, with an aim to plant 10,000 new street trees by 2030. Land-use conflicts are also considered, either through a land swap program or the densification within the city. These actions are accompanied by an envisaged increase in trees, both inside and outside the urban area. The municipality aims to expand the area of urban forests by 200 acres per year until 2030.

Paris Region is set on depaving areas within its urban region. This involves identifying suitable sites, and 100 of these will aid in highlighting the effects. This practice is also aimed in schoolyards, as this would help mitigate the effects of climate change, as identified within e.g., the Oasis schoolyards programme. Outside of depaving, Paris Region aims to establish 100 ha of green roofs, 35 ha of urban agriculture and one million street trees, recognising the WHO goals (see Table 1) without formalised policy or legalisation. Another focus is on brownfields, as their development is in line with the net zero land take policies. However, Paris Region is also set to balance the development plans with protecting brownfields, as they can feature a wide variety of species and show a high biodiversity.

4.3 Ambition targets - the 3-30-300 rule

Through REGREEN we have been able to test the ability to implement the 3-30-300 guidance, in each of the three European ULLs. This guidance implies at least 3 trees in view, a 30% canopy cover in the neighbourhood, and 300 m distance to the nearest public green space (Konijnendijk 2021). Here we present some initial mapping results for each city, with a brief description of how the rules were implemented, and some possible implications or challenges that cities would face in achieving this type of ambition.

4.3.1 What are the rules and how they were implemented

The 3-30-300 rule is a simple, easy-to-remember and easy-to-understand, comprehensive guideline which outlines that each workplace, school, or home should have at least three viewable trees, 30%

neighbourhood canopy cover, and be within 300 m from their nearest green space (at least 1 ha) (Konijnendijk 2021, 2023). Studies so far have measured the extent to which cities meet each rule, independently. We believe that all three rules interrelate and should be measured sequentially and have re-ordered them to 300-3-30.

Achieving the 300 rule in high-density cities or inner-city areas is difficult due to lack of available space. To achieve the 300 rule in this exercise, large blocks of land parcels, often containing built surfaces, have to be converted to grass. We use grass because having some open green space is needed in urban areas, and some will be converted to trees in later iterations of the set of rules. To determine which blocks to convert, we first delineate blocks of land (at least 1 ha in size), fully enclosed by road. We create a regularly partitioned grid, selecting a single block with the smallest population that intersects each cell and convert to green space. The dimensions of the grid cells (212x212 m) ensure that any block which intersects any part of a cell, when buffered 300 m, will serve any house within that cell. Ultimately, the goal is to minimise the number of blocks needing converting and the number of citizens disrupted.

For the 3 rule, we adopt a straight-line buffer approach mentioned in Battisti et al. (2023) and Konijnendijk (2023) and define the rule as the presence of three trees within a 30 m buffer from every residential building. We assume that three trees are equal to two or more, 5x5 m coniferous or deciduous pixels. For buildings which are not served by the 3 rule, we convert, where possible, non-built pixels within the 30 m buffer such as agricultural land, grass, and shrubs to deciduous trees. If there are no non-built pixels present, we convert mineral surface which typically consists of roads and parking lots.

The 30 rule, as defined in Konijnendijk (2023), is a target of 30 % canopy cover in each neighbourhood. This rule is difficult to achieve due to spatial and environmental constraints. In the spirit of having green or blue space (rather than specifically trees) in a neighbourhood, we have modified the rule to a total 30% cover of green (grass, shrubs, and trees) or blue space (river, lake, and sea) because blue spaces have also been found to have similar beneficial impacts to green spaces. One of the key challenges of the 30 rule is the definition of a neighbourhood. We define a neighbourhood as a 300 m buffer from every block of buildings (all buildings fully enclosed by roads). The buffers are created using building points or polygons and do not incorporate domestic gardens. However, domestic gardens, where present, will still contribute to each neighbourhood's 30 rule as they are captured in the land cover classification as grass, trees, or shrubs. This approach acknowledges each block as its own unique neighbourhood, enabling the study to explore disparities in the compliance of the 30 rule on a small and consistent scale, and a technique which is highly transferrable and can easily be replicated in other cities.

4.3.2 Mapping results

The feasibility of achieving the 3-30-300 rule in the three cities depends on existing green and blue space which are greatly influenced by factors such as spatial, environmental, and social constraints. For example, in Northern European cities such as Aarhus Municipality, the biophysical conditions, existing presence of rich forestland, and the positive attitudes towards living near forests (Kabisch et al. 2016) may result in notably less change needed to achieve the 3-30-300 rule. This rule is applicable for both cities landlocked and along shorelines.

Figure 10 exemplifies the process in a randomly selected location in Aarhus Municipality, comparing land cover in the baseline and after the implementation of the 3-30-300 guidance. In Figure 11, changes made in the 300 rule are evident as a block of buildings (black) in the south has been converted to green space (green). Also, changes made in the 3 and 30 rule are evident as some bare soil and mineral surface (light brown and light grey, respectively) have been converted to deciduous trees (dark green).

Despite many locations in Aarhus Municipality requiring relatively small changes to satisfy the 3-30-300 rule, high-density, inner-city areas in Aarhus Municipality (Figure 10; Figure 11) possess very little urban green space. This is also true for the central part of Paris Region. To meet the definition of accessible green space, roof gardens or similar interventions would need to be publicly accessible.

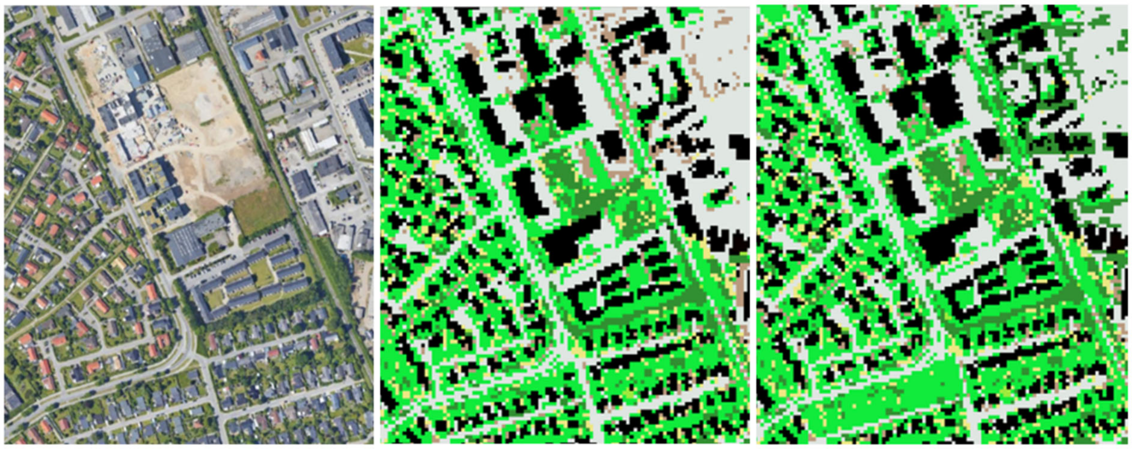

Figure 10 Google Satellite imagery, baseline, and final scenario of location in Aarhus Municipality which requires change from all three rules.

Figure 11 Google Satellite imagery, baseline, and final scenario in the city centre of Aarhus Municipality

4.3.3 Implications or challenges in achieving 3-30-300 rule

Each European ULL is unique, thus, present their own unique challenges when implementing the 3-30-300 guidance. The feasibility of the guidance heavily relies on spatial, climatic, and social constraints. Achieving the rule would have substantial implications on the equitable provision of green and blue space to citizens and provision of social, economic, and environmental ecosystem services. However, it is important to recognise some of the associated challenges with implementing these rules.

One of the main challenges regarding the 300 rule is the omittance of any green space smaller than 1 ha. Particularly in inner-city, high-density areas, the supply of green space greater than 1 ha is limited. Green space smaller than 1 ha may be necessary and more suitable for inner-city areas as they still provide green space for citizens to meet (Ekkel and de Vries, 2017). Another challenge of the 300 rule is the simplified assumption that citizens will use the nearest green space which is not always true (Zhou and Kim, 2013).

For the 3 and 30 rule, the key challenges are associated with definitions: how to define tree visibility from a citizen's home, how to define a neighbourhood, and which land cover do you include in the green/blue cover. Like the 300 rule, the thresholds used in the definitions impact the changes made to each ULL. Perhaps a higher degree of flexibility with the thresholds would encourage and enable cities with different constraints to strive to achieve the 3-30-300 rule.

4.4 Equity targets

A status quo analysis for the defined ambition target accessibility to nearest public green spaces within 300 m is a baseline. The equity target enriches this spatial connotation by socio-demographic and socio-economic linkages. Hence, the equity target goes a step further and defines different socio-spatial contexts such as different population groups for an ambition target.

Equity targets aim to eliminate disparities in access to public urban green spaces, ensuring that all population groups have equal opportunities to enjoy the cultural ecosystem services provided by these spaces. Previous studies have examined the potential for green spaces to reduce health inequalities – with a recent review showing more beneficial impacts on health for lower socioeconomic groups, and that this is particularly true of studies in the European context (Rigolon et al, 2021).

Achieving equity requires careful planning and policy implementation, with a focus on the following multiple constraints. Firstly, geographic distribution plays a vital role. To ensure equitable access, green spaces must be distributed geographically to reach all neighbourhoods, including those historically marginalised or underserved. A threshold might involve setting a maximum distance that residents should travel to reach a public urban green space. Furthermore, equity targets should address not only the quantity of public urban green spaces but also their quality. Small, poorly maintained spaces may not provide the same cultural ecosystem services as larger, well-maintained ones. Establishing minimum size and quality standards can be a crucial threshold. In terms of accessibility and inclusivity, physical accessibility is paramount.

General targets on equity focus either on simple green space area per capita thresholds, ranging from at least 9 m^2 per capita to an optimum of 50 m^2 per capita (WHO 2012). Another approach lies within service areas, which analysis the distance of resident to the nearest public urban green scape larger than a given area. Some thresholds include 300 m to a green space of at least 1.5 ha, or 500 m to a green space of more than 5 ha (WHO 2016, WHO 2017).

Table 5 summarises baseline indicators for green spaces and public urban parks for the three ULLs.

Table 5 Excerpt from the baseline indicators

	All indicators for the urban footprint	Aarhus Municipality	Paris Region	Grad Velika Gorica
1	Area and share of green and blue space			
1.1	Area of green space land cover (ha)	6,918.80	144,823.60	498.70
1.2	Area of green space land cover/inhabitant (m²)	215.90	124.80	159.10
1.3	Share of green space land cover (%)	42.50	50.20	42.90
1.4	Blue and green space land cover (%)	43.30	52.10	43.00
1.5	Area of blue and green land cover (ha)	7,054.70	150,400.50	500.60
1.6	Canopy cover within city limit (m²/inhabitant)	70.38	58.54	38.79
2	Area and share of public urban parks			
2.1	Area of public urban parks (total ha)	4,043.02	33,042.00	78.58
2.2	Area of public urban parks (% urban footprint)	24.80	11.45	6.76
2.3	Area of public urban parks per inhabitant (m²/inhabitant)	126.19	28.47	25.07
2.4	% population living within 300 m (Euclidian distance) of an urban public park of at least 1.5ha	92.80	38.60	67.70

Within the REGREEN project, vital statistics on age groups and education level were collected and disaggregated to address level. With this data, it was possible calculate the number and share of all residents and residents within different age groups and different education levels with access to a public urban green space of at least 1.5 ha within 300 m Euclidean distance from their home address. For better comparability between the ULLs, the analysis was restricted to the area of the urban footprint, which reflects the urban area of the ULLs.

For the total population, Figure 12 shows that the 300 m equity target is met for around 93 % of residents in Aarhus Municipality, around 39 % of residents in Paris Region and 68 % of residents in Grad Velika Gorica. Differences between age groups are small but vary between ULLs. For Aarhus Municipality, the proportion of residents within 300 m is lowest for residents between 15 and 65 years. For Paris Region it is lowest for residents above 64 years and for Grad Velika Gorica it is lowest for residents under 15 years.

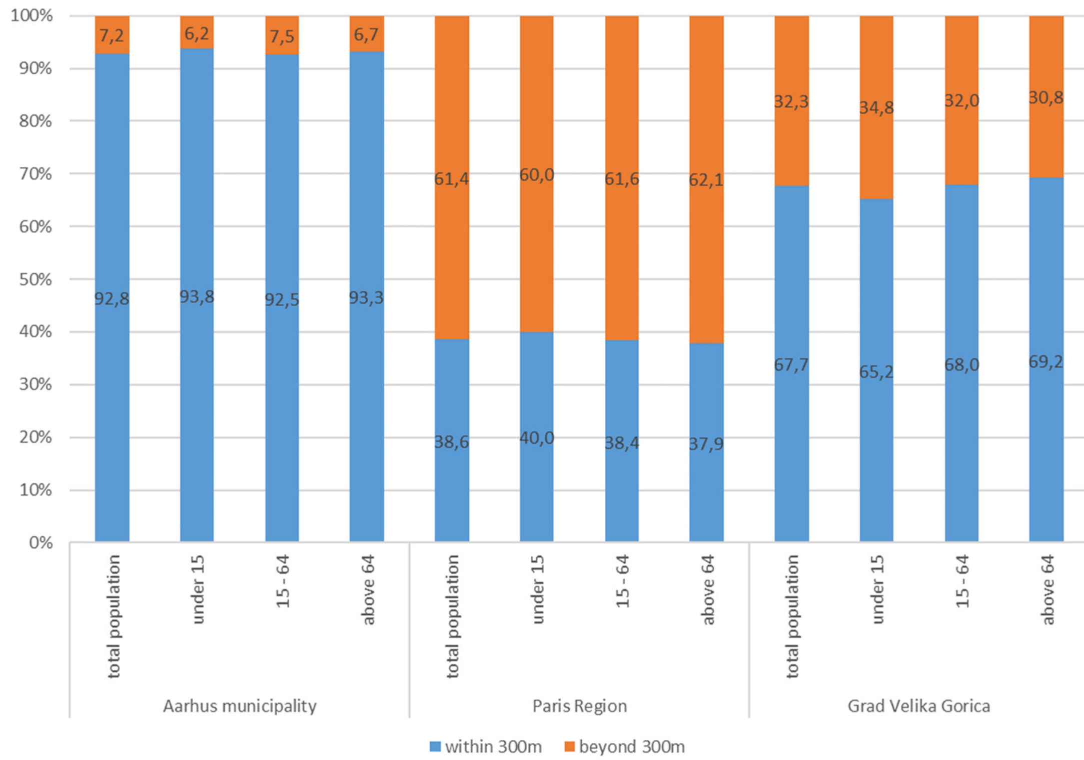

Figure 12 Proportion of different age groups within and beyond 300 m from public urban green spaces ≥ 1.5 ha within the urban footprint across the three European ULLs

Figure 13shows that differences in access to public urban green spaces ≥ 1.5 ha within 300 m between population groups with different education levels are small. However, for both Aarhus Municipality and Paris Region, the proportion of residents within 300 m is lowest for residents with the highest (tertiary) education level.

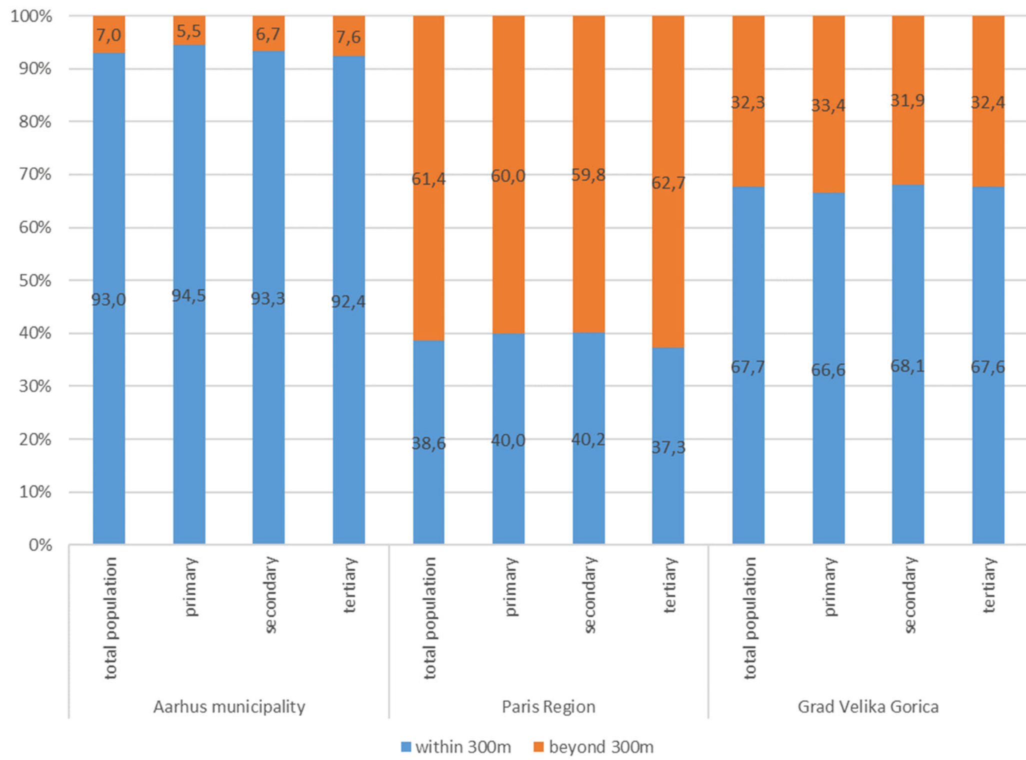

Figure 13 Proportion of groups with different education levels within and beyond 300 m from public urban green spaces ≥ 1.5 ha within the urban footprint across the three European ULLs

It can be concluded that the ambition target of access to a public urban green space ≥ 1.5 ha within 300 m for different age groups is almost met for Aarhus Municipality. This is not the case for Grad Velika Gorica, where the target is not met for almost 1/3 of the residents and for Paris Region, where the target is not met for more than 60 % of residents. In terms of equity, results point at some differences across age groups and education level. However, these differences are rather small and do not point a major challenge regarding equity for access to parks for different age structure or with different education levels.

There are some limitations related to this analysis. Use of the Euclidean distance may not fully reflect differences in the time it would take to get to parks from different neighbourhoods. Data on age and education levels were derived from aggregated (e.g., district) scale and disaggregated to address level. This causes a loss of spatial detail, i.e., that differences between age groups and education levels might be higher in reality than the results show. Also, to ensure comparability across ULLs, the applied division into age groups and groups of education level is rather coarse. A higher level of detail might have shown larger differences between population groups. Finally, the only applied criterion for quality of public urban green spaces is size (i.e., in choosing to measure access to green spaces ≥ 1.5 ha). Additional measures, such as vegetation distribution and composition, degree of maintenance or presence of features, such as playgrounds, trails, benches etc. could have brought more insight into quality of public urban green spaces. Including such measures was not possible due to limited access to consistent data across parks and/or ULLs. Further insights also may be gained by linkage to other socioeconomic data, such as income or ethnicity, but such data is not uniformly available across ULLs.

4.5 Ecosystem service targets

Through the modelling in REGREEN it is possible to summarise the variation in ecosystem services provided by NBS across the different ULLs. This can be used to estimate the service provided by current NBS. A range of different metrics can be calculated to help understand the amount of service provided, in the wider context of the intensity of the pressure, and the people who can benefit from it. These include efficiency metrics which allow direct comparison across cities of very different size and proportion of NBS.

Examples are shown below (Table 6 and Table 7) for the ecosystem services of air pollution removal and water quality improvement by NBS. These illustrate the type of summary metrics, and how they can be used to compare across cities, but also to inform target setting for ecosystem services delivery. For the air pollution removal, data are summarised for the service provided by trees located within the urban footprint. The cities vary considerably in urban tree cover, and the quantity of PM2.5 pollution removed is - to a large extent - a function of tree cover. This pollution removal then influences the change in PM2.5 concentration that can be attributed to trees within the urban footprint. Understanding the range in service provided across the three European ULLs helps in understanding the possible service that can be provided in each context. For example, the change in concentration of PM2.5 varies from 0.004 to 0.182 $\mu g/m^3$ reduction, and the range in efficiency of pollution removed per ha of woodland varies from 1.5 to 5.4 kg PM2.5 per ha. When looking at the efficiency metrics, it is clear that trees in Paris Region are more efficient at removing PM2.5 overall than in the other cities.

Note that the basic metrics, and the efficiency metrics, may need to be different for other services. For water quality improvement, the metrics relate to proportion of tree cover in the catchment, rather than total area of trees. The efficiency metrics are expressed per 10% change in tree cover. There are separate metrics for each of the suite of water quality parameters. Some of these can be expressed as efficiency metrics (per unit area/proportion of contributing NBS), while for others, it is not appropriate to do so since the relationships are not linear.

These data are more useful in informing target setting for cities if they are considered as understanding the scope of what is possible in different contexts, rather than necessarily picking a value from a particular city as a target. One reason for this is that some efficiency metrics are also related to the amount of pressure. Air pollution removal is one example, where trees become more efficient at removing pollution if the pollution concentrations are higher. In that case, a declining efficiency over time might be a good thing, if it reflects a reduction in the overall pollutant pressure over time.

Table 6 Summary metrics indicating pressure, ecosystem service provided and health and economic outcomes (where available) for air pollution removal.

Theme	Metric	Aarhus Municipality	Paris Region	Grad Velika Gorica
Pressure	Average PM2.5 concentration (µg/m³ - modelled)	8.52	9.41	18.38
Area of NBS (trees)	Tree cover (ha) - current urban trees	1,688	54,216	20
	Tree cover (%) - current urban trees	10.36	18.79	1.74
Total service provided	Total quantity of PM2.5 pollution removed (kg)	5,986	295,410	31
Efficiency	Average PM2.5 concentration change (µg/m³)	-0.04	-0.18	0.00
	Average percentage change in PM2.5 concentration (%)	-0.41	-1.93	-0.02
	Pollutant removed per ha (kg/ha)	3.55	5.45	1.55
	Concentration change per 10% urban trees	-0.03	-0.10	-0.02
	% concentration change per 10% urban trees	-0.40	-1.03	-0.11
Population affected	Urban population	130,172	6,599,815	4,259
	Peri-urban population	23,982	614,995	29,339
Health outcomes	Avoided Respiratory hospital admissions	-	-	-
	Avoided Cardiovascular hospital admissions	-	-	-
	Avoided Life Years Lost	-	-	-
Economic value	(Euro) - urban area	430,000	-	-
	(Euro) - urban & peri-urban area	-	-	-
Efficiency of value per ha	(Euro/ha) - Trees	255	-	-
	(Euro/ha) - All vegetation	-	-	-

Table 7 Summary metrics indicating pressure for water quality improvement. Values are indicative until models are finalised

Theme	Metric	Aarhus Municipality
Pressure	Modelled water chemistry parameter without urban trees	
	Dissolved oxygen (DO, mg/L)	7.57
	Water temperature (Tave, degC)	19.82
	Chlorophyll-a (Chl-a, mg/L)	0.01
	Total Nitrogen (TN, mg/L)	0.45
	Total Phosphorus (TP, mg/L)	0.26
Area of NBS (trees)	Tree cover proportion (%) - current urban trees	11.00
Total service provided	Dissolved oxygen (DO, mg/L)	1.32
	Water temperature (Tave, degC)	-3.03
	Chlorophyll-a (Chl-a, mg/L)	-2.86
	Total Nitrogen (TN, mg/L)	-8.44
	Total Phosphorus (TP, mg/L)	-6.92
Efficiency	%TN change per 10% catchment tree cover	-7.68
	%TP change per 10% catchment tree cover	-6.29

4.6 Biodiversity targets

Integrating biodiversity indicators and target values into urban planning is crucial to support NBS. By doing so, we can ensure that our cities not only thrive but also contribute to the preservation of ecosystems. These indicators provide a measurable framework for sustainable development, helping us monitor and protect our natural environment while enhancing the quality of life for urban residents. NBS are most effective when they align with biodiversity goals, making the inclusion of these indicators a fundamental aspect of creating resilient and harmonious urban landscapes.

4.6.1 Background knowledge on existing targets from ULLs

Various indicators exist to measure the state of biodiversity in a given area, though it is impossible to measure the full effective biodiversity of an ecosystem. The quality of the diagnosis will depend on the choice of the appropriate indicator for a given sample and study area, subject to the availability of the data. Various indicators are commonly used to characterise urban biodiversity like species richness and diversity, abundance, taxonomic diversity, functional diversity or species composition. Depending on the analysis and conservation objectives, other indicators may prove relevant, such as the rate of nativeness in a community of species, the proportion of invasive exotic species or protected species, hence the importance of clearly defining your initial question and the conservation objective sought. Specifically, quantifying the linkages between biodiversity and ecosystem service metrics is still poorly covered in the scientific literature (Díaz et al., 2007; Schwarz et al., 2017), as it represents only 5% of urban biodiversity studies (Rega-Brodsky et al., 2022). In some studies, the indicators used to quantify biodiversity are predominantly taxonomic diversity and the presence of green spaces and are associated with specific ecosystem service, such as cultural services (recreation, health, well-being), erosion prevention, soil fertility maintenance, and pollination (Schwarz et al., 2017). However, these indicators are limiting and often do not allow for a real causal relationship between bid and an ecosystem service. More recent and systemic approaches, such as functional ecology, attempt to quantify these relationships more directly by studying the functional aspects of biodiversity, specifically plants (Miedema Brown & Anand, 2022) and answer two main questions: What are the environmental factors that control the distribution and functioning of plants? What is the impact of plants on the functioning of ecological systems (Garnier et al., 2016)? However, there is still not enough insight and data to propose generalisable indicators with operationally usable thresholds.

Thus, we primarily focus here on species richness indicators related to the size, shape, and connectivity of green spaces, as they have been the subject of more studies and for which generalisable threshold trends are established. In particular, variables such as green patch area (Beninde et al., 2015; Vega & Küffer, 2021), plant cover (Szulczewska et al., 2014; Threlfall et al., 2017), the presence of rare habitats (Alikhani et al., 2021; Le Roux et al., 2015; Oertli & Parris, 2019; Stagoll 2012) or the connectivity (SRDIF 2023) have been identified as determining factors of the biodiversity of an area (

Table 8) and applied to the Paris Region ULL as part of the Institut Paris Région's work on the Cartoviz interactive mapping tool.

Table 8 Background knowledge based on REGREEN Deliverable 3.2 Guidelines for a Depaving and Re-greening Strategy in Cities

Criteria	Thresholds	Score	Source
Surface area of planted areas	Absent	0	Vega & Küffer, 2021); Spotswood et al., 2019; Beninde et al., 2015
	<= 4.4 Ha	1	
	> 4.4 Ha - < 53.3 Ha	2	
	>= 53.3 Ha	3	
Plant cover (%)	< 25 %	0	Threlfall et al., 2017; Szulczewska et al., 2014
	> 25 % - < 45 %	1	
	>= 45%	2	
Rare habitats	None	0	
	Notable trees	1	Spotswood et al., 2019; Stagoll et al., 2012; Le Roux et al., 2015
	Ponds	1	Spotswood et al., 2019; Ramsar Convention on Wetlands, 2018; Oertli & Parris, 2019; Alikhani et al., 2021
	Wetlands	2	
Connectivity	Areas of ecological interest under urban pressure	0	Cornet, 2021
	No areas of ecological interest under urban pressure	2	

To understand the complexity of how ecosystems function and their interactions with the urban environment, studies of specific urban spaces need to be conducted on a finer scale. Specific ecosystems have been recognized in the literature as potential ecological corridors and welcoming reservoirs of biodiversity, such as large urban parks, gardens, private courtyards, and street trees, among others. In this section, we focus on research conducted at the National Museum of Natural History of Paris concerning urban wastelands, green roofs, and small urban parks.

Work has been carried out on qualifying urban flora (Muratet et al., 2008), through for instance the creation of an Index of Floristic Interest, which incorporates four equally weighted variables (species richness, typicality, indigeneity and rarity). More specifically, the flora of 98 wastelands in Greater Paris Region was analysed, showing that their floristic richness represents 58% of the total richness observed in the whole study area, which makes wastelands the richest habitat in the department (Muratet et al., 2007). They identified various factors influencing floristic interest of wastelands in a densely populated urban area:

- Anthropogenic parameters: sites age and areas had significant impact on wastelands floristic richness. The older and the bigger, the richer the flora was;
- Isolation by distance, migration among wasteland and non-wasteland sites: the nearest large sites (>2 500 m²) are more likely to have a similar floristic richness, whose composition is less influenced by surrounding sites. In addition, the presence of a wetland, allowing the arrival of species not characteristic of wasteland, influences the area's floristic richness. Finally, the presence of individual and collective habitats significantly negatively influences the floristic rarity of surrounding wastelands.

Part of the work also focused on determining the biodiversity and connectivity potential of green roofs. For instance, an automated method for identifying green roofs in urban environments using infrared aerial photographs and building shape data has been created (Louis-Lucas et al., 2022). Louis-Lucas also applied the landscape graphs theory (Mayrand & Clergeau, 2018) to green roofs and ground green space to measure their effective and potential impact in the Paris Region green network. Various target values have resulted from their studies:

- A green roof participates in the green network (connectivity) if no more than 20 m high. Green roofs can significantly contribute to landscape connectivity. Even if they have less strategic role than ground green space, they participate to dispersal flows rather than centrality, especially for mobile species. The surroundings of the studied green roof also have a significant influence. A green roof contributes much less to the ecological network when surrounded by high-rise buildings;
- The integration of wild species on green roofs is a good way to improve local biodiversity but also to implement more functional green networks.

Work has also been carried out on small public gardens in Paris Region (0.5-2.0 ha) and has shown the importance of the impact of management practices on the taxonomic diversity of these spaces (Shwartz et al.,2013). Finally, beyond the fact that this type of green space could host a rich ordinary biodiversity, this work showed that spaces managed with a conservation program, like ecological management, could host a greater diversity as well as bird and butterfly species less tolerant of urban ecosystems. Below is a list of variables that can improve biodiversity in these Parisian green spaces:

- Local management variables rather than landscape variables;
- Lawns rich in wild plants;
- No use of pesticides;
- Habitat and soil diversity.

Urban ecology is, however, a relatively recent discipline that still requires substantial data collection and analysis of ecosystem interactions with their environment. We have relied on the most widely studied and threshold-based indicators to apply them to the ULLs.

4.6.2 Key findings from the ULLs

Ecological thresholds represent critical points beyond which ecosystems undergo rapid changes, potentially leading to biodiversity loss. Understanding and managing these thresholds is essential for maintaining healthy urban green spaces. One crucial ecological threshold in urban green spaces is the minimum area required to support specific species or ecological processes. Smaller green spaces may be unable to provide sufficient resources or habitats for certain wildlife, although plenty of exceptions exist. For example, some bird species require larger areas for nesting and foraging. Failure to meet this minimum area threshold can lead to local extinctions and reduced biodiversity (Beninde et al 2015). Maintaining connectivity between habitats is vital for wildlife movement in urban environments. Fragmented green spaces can hinder species from moving between areas. Ecological corridors, such as tree-lined streets or green roofs, help bridge these gaps. Habitat quality significantly influences biodiversity in urban green spaces. Even a large green area may fail to support diverse species if habitat quality is poor due to pollution, invasive species, or habitat degradation. Within the REGREEN project, we applied area, canopy and grass cover thresholds for green spaces within the European ULLs. The following maps and figures show the distribution, both spatial and categorical, across the ULLs. Owing to the variety in biodiversity thresholds or the lack thereof, the REGREEN project opted to focus on a specific set of parameters, which obtainable throughout all 3 EU ULLs. The analyses focused thus on the parameters of size, canopy and grass cover. Both the local administrative unit (LAU) and the urban footprint were considered as seen in Figure 14.

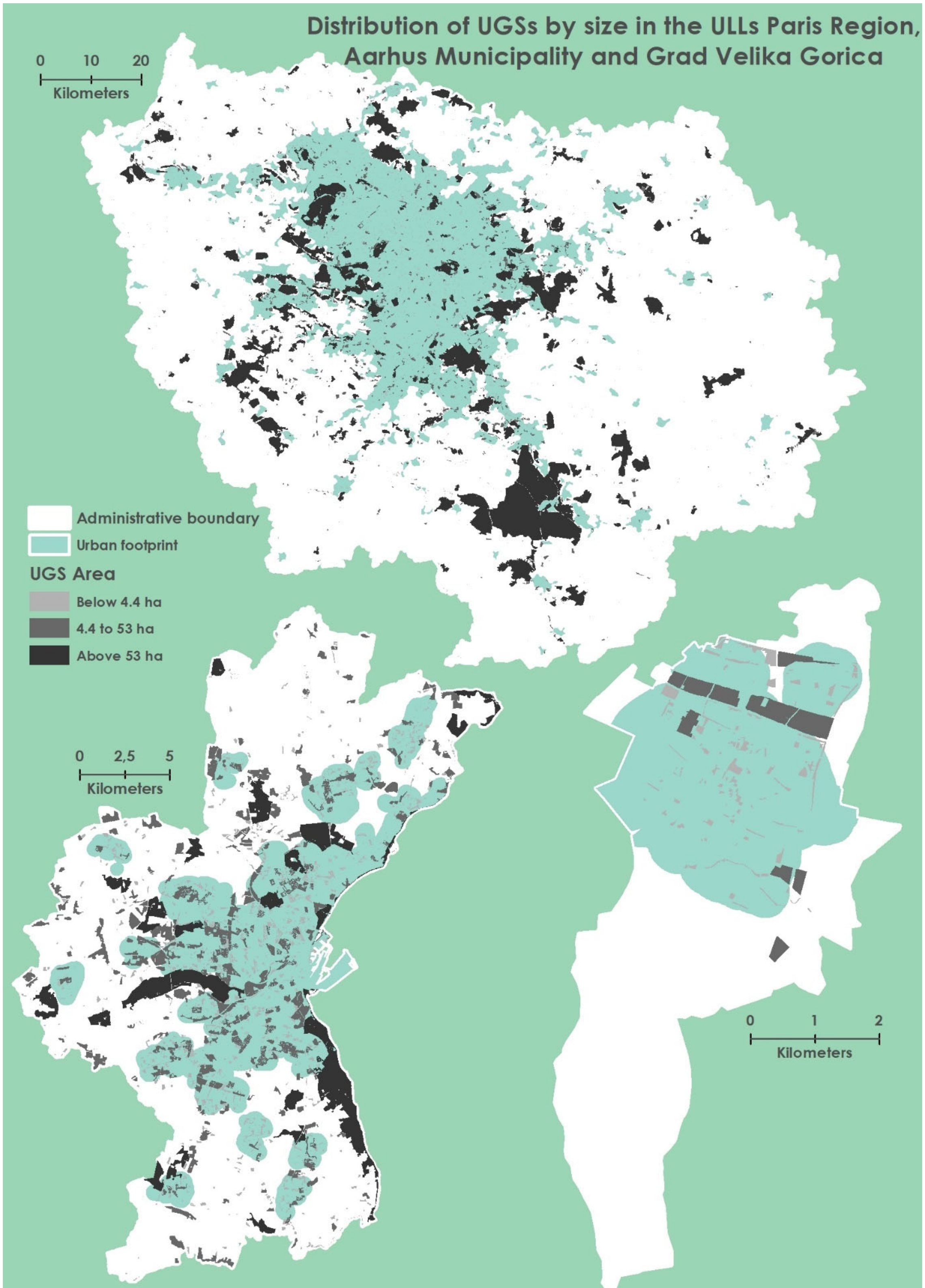

Figure 14 The 3 EU ULLs and their urban green spaces by size

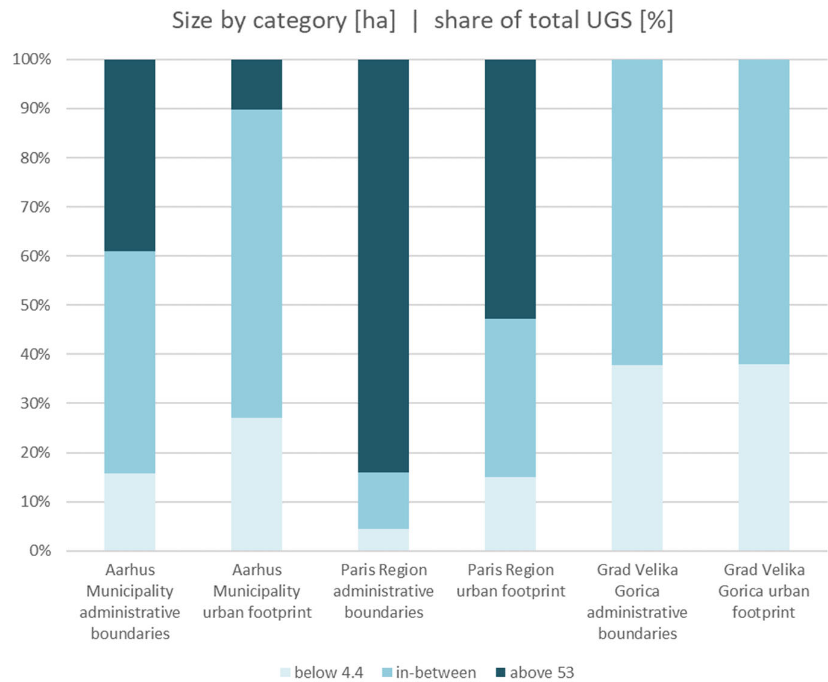

Figure 15 Distribution of urban green spaces by size within the ULLs, both within their LAU (local administrative unit) and their urban footprints

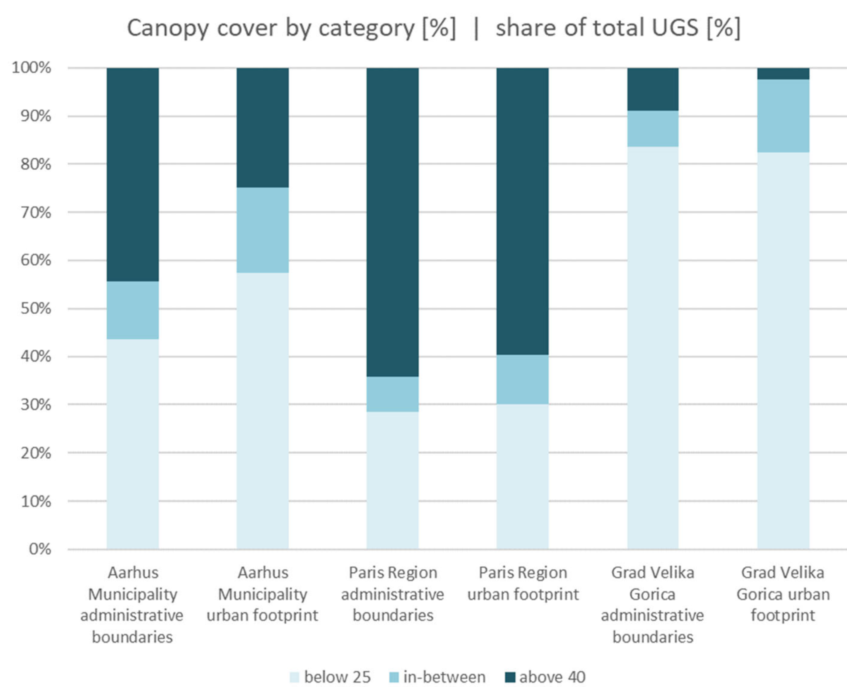

Figure 16 Distribution of urban green spaces by canopy cover within the ULLs, both within their LAU and their urban footprints

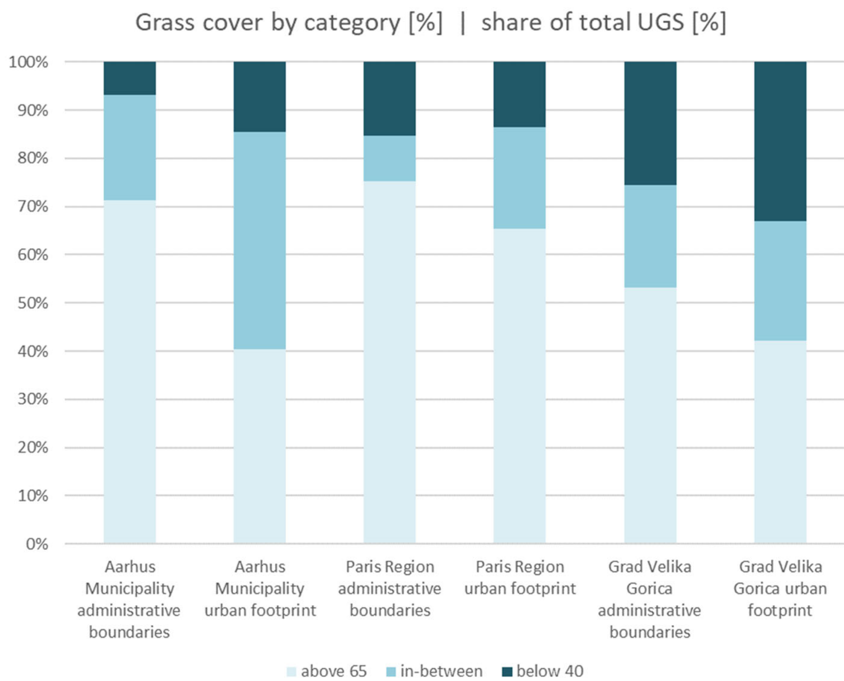

Figure 17 Distribution of urban green spaces by grass coverage within the ULLs, both within their LAU and their urban footprints

Focusing on the urban footprint and the administrative area LAU alike, the urban footprint is more suitable for comparing differences between the ULLs ("inter"), while the focus on the administrative area LAU gives a more complete picture for intra ULL analyses. The map in Figure 14 shows the spatial distribution of urban green spaces within the ULLs. A clear pattern is visible when focusing on the three different categories of the size of green spaces as identified in

Table 8, namely urban green spaces with less than 4.4 ha, 4.4 to 53 ha and above 53 ha (see Figure 15, Figure 16 and Figure 17). The biggest category is mostly present towards the boundary of the urban footprint or beyond, thus mainly existing at the urban-rural fringe. As Paris Region is both the largest ULL, and the ratio between the size of the urban footprint and the administrative boundary is the biggest, there are more potential areas available to support large urban green spaces. The smallest category is usually found where building density is at its highest, towards the centre of the ULL, with medium sized urban green spaces being present mostly in-between.

The urban green spaces themselves don't show a great difference in the grass cover, which can support certain species when it is the lowest. Yet, the canopy cover in Figure 16 shows clear differences, both between ULLs and intra ULLs.

The specific set of indicators used here are easily available for other urban areas and can give a first insight into where NBS interventions might be most needed. However, on ground data such as management practices, species count, and further metrics of a given urban green space would provide more clarity into the spatial distribution of locations with higher or lower biodiversity.

4.7 Organisational targets

4.7.1 Integration of NBS in other policies, sectors and types of intervention

During the last decade, the concept of NBS has increasingly made its way into government agendas and decision-making through e.g., local planning processes, as governments are getting more conscious about e.g., sustainable development, Agenda 2030, climate adaptation etc. and potential solutions. However, often NBS require more integrated approaches to local policy making than other types of solutions to ensure that nature renewal and preservation is aligned to maximise benefits for other sectors and associated priorities.

In REGREEN (see D.6.2, D6.3), compartmentalisation and the fragmentation of local government into silos have been identified as a major factor that limits and complicates the uptake and implementation of urban NBS, and has been identified as a problem for dealing with environmental protection efforts more generally in relation to sustainable transitions (Russel et al., 2020; Mickwitz et al., 2009; Alons, 2017; Sarabi, 2019). Local government institutions have been especially challenged by the integration of sustainability – e.g., connected to NBS – policy issues and aims across a range of urban policy sectors (Peters, 2018; Candel, 2019; Wamsler, 2015). On the other hand, there is a potential in well-designed NBS to foster integrated and multi-functional policy solutions. Hence there is a need for more integrated governance approaches to facilitate the creation of and implementation of NBS initiatives. Institutional approaches to integrating policy making can focus on organisational processes to coordinate policy making between administrative units, policy instruments to influence the behaviour of actors within sectors and stakeholder processes to embedded stakeholders within decision-making and implementation processes.

4.7.2 Organisational processes for policy coordination targets

The existing literature is rife with suggestions on administrative conditions and processes that promote policy coordination (e.g., Peters, 1997, Russel and Jordan 2009; Russel et al 2020), many of which were also identified as important facilitators of urban NBS by REGREEN analysis in D6.2. (Kirsop-Taylor et al., 2021) and D6.3. We can distil this literature to establish several targets for NBS governance, although it is hard to put a value on different measures beyond simple nominal scales, e.g., ‘not present’, ‘partly present’ and ‘present’. It is also important to note that these targets are necessary for achieving coordination around NBS but are by themselves insufficient with other social and external factors also being important around the acceptance of NBS measures (e.g. D6.3).

Taking a steer from Russel and Jordan (2009) and using findings from D6.2 and D6.3 as well as adapting lessons from the wider literature on policy coordination, we can organise the targets around more centralised and more diffuse organisation processes for NBS policy coordination.

More centralised organisational coordination targets can include:

- High-level and sustained support for NBS and cross-sector in the political arm of a municipality;
- High-level and sustained support for NBS and cross-sector in the administrative arm of a municipality;
- Assignment of NBS policy coordination to a high-level administrative unit in a municipality (e.g., the Finance Office or the Major’s Office) to encourage other parts of the administration to engage with NBS policy and initiatives;
- NBS coordination units to act as a centre of expertise of the municipality authorities and wider stakeholders, and delegate appropriate agenda-setting/decision-making power to the unit;

- NBS (Cabinet) committees chaired by the Major or Deputy Major and populated with political leaders of the municipality's different administrative units to resolve any conflicts between different sector priorities and to set strategic goals;
- Cross municipality committees populated by public officials to share best practice and goals, and to facilitate common NBS across administrative borders;
- Cross-municipality fora to secure broad NBS political support for cross-municipal-border NBS or for NBS more broadly in the region.

More diffuse organisational coordination targets can include:

- A process of NBS knowledge exchange and generation within the organisation to help sector actors in municipalities join-up activities and understand the benefits of NBS, through for example existing processes such as environmental impact assessment and strategic environmental assessment;
- Capacity building through, e.g., training so that public servants in municipalities can better understand the relevance of NBS to their sector and related priorities, and to learn new positive ways of working to better engage with and promote NBS. In REGREEN, we observed how walkable floor maps could be used for this purpose (see D6.3);
- Dedicated NBS budgets, so that NBS initiatives are not competing with traditional sectorial ones within the municipality.

4.7.3 Policy instruments targets - influencing behaviour of actors within sectors

A key factor related to the success of any policy initiative is how social actors behave in their response to the initiative. This issue is pertinent to NBS particularly in relation to how they are received by social actors, but also how they are used. For instance, NBS such as green corridors can open up spaces for non-motorised transport (cycling or walking) between areas in a municipality. However, several factors can determine whether this space is used as intended, including how safe citizens feel, convivence of traditional modes of transport, etc. Therefore, incentives are needed to both encourage engagement with the NBS to disincentivise bad practice. To achieve this, public authorities can use varied policy mixes, assemblages of policy instruments (Pedersen et al., 2020), to incentivise engagement with NBS goals by social actors.

The three most common types of instruments used in environmental policy (Jordan et al., 2013); mixes of knowledge- based instruments (KBIs), market-based instruments (MBI), regulatory instruments (RI).

KBIs, generate knowledge about projects aimed at engendering community-scale stakeholder support, to reporting, or brokering results and evidence about NBS experiments to influence national policy making and policy development activities. They included public awareness campaigns, information about NBS options for community groups, information for citizens about new NBS regulations etc. (see D6.2, Kirsop-Taylor et al 2021). While MBIs are commonplace in environmental policy making (e.g., taxation, subsidies, pollution permit trading schemes), our findings in D6.3 suggest that there is some, but limited, use of these instruments for NBS in urban areas. RIs, are more top-down policy instruments through which public authorities can intervene to coerce actors to achieve set targets and/or behaviours (e.g., through often but not exclusively through legal means). D6.2 (Kirsop-Taylor et al 2021) shows many studies have observed the use of RIs by municipalities to manage NBS, e.g., regulations around natural urban drainage (Davis & Naumann, 2017; Papparlardo

& La Rosa, 2020), afforestation (Baulenas & Sotirov, 2020), building regulations for green roofs (Suleiman et al., 2020).

Target values for these instruments are hard to determine, but might include factors such as:

- The number and strength of different instruments supporting NBS in a municipality;
- The absence/removal of policy instruments making obstacles to NBS;
- The mix of instruments (e.g. KBI, MBI, RI) supporting NBS in a municipality, where the logic suggests that the greater the mix the broader the range of incentives and flexibility to meet NBS objectives.

4.7.4 Stakeholder engagement targets

Findings from Regreen (D6.3) show the importance of stakeholder engagement for NBS, a factor also emphasised in the wider literature (e.g., van der Jagt et al. 2017). Stakeholder engagement is important for creating joint value to the decision-making process and networks that integrate societal and public actors in the implementation through wider collaboration with relevant stakeholders (including business, citizens and third sector organisations) which may or may not include scientists and or public authorities (Ramaswamy and Ozcan 2014). Stakeholder engagement can also to help come up with novel and innovative decision outcomes (James *et al*, 2017).

As with other organisational and governance targets, stakeholder processes can differ, but can be hard to put a value on. However, types of stakeholder engagement (e.g., Arnstein 1969; Baglioni and Sinclair, 2018; Giest, 2017; Graefe and Levesque, 2010; Higdem, 2017; Hinterleitner, 2018; Sørensen and Waldorff, 2014; Torfing and Ansell, 2017) can be placed on a continuum e.g., no engagement, informing, selective insider group inclusion, public consultation, stakeholder learning and knowledge exchange, inclusive partnership, delegated power and citizen control. Higher levels of engagement are not necessarily *better* than lower levels – the optimal level of engagement depends on the situation. A more horizontal governance - in contrast to top-down - is argued by some scholars to increase the efficiency and innovativeness by drawing on the inputs stakeholders more broadly can contribute through their skills and knowledge. However, relying on e.g. network governance in its pure form can also constitute a barrier to effective implementation of policies (e.g. Bednar et al., 2019; Sørensen & Torfing, 2019). On the other hand, if municipalities are assigned a role in this process, they can potentially ensure cohesion and commitment through their experience in coordination, and through the legitimacy and regulatory authority their participation can add to a process (e.g. Scharpf, 1997; Sørensen & Torfing, 2019; Bednar et al. 2019). If municipalities e.g. are not involved, it is important to be aware that stakeholder power varies – there is a risk that powerful stakeholders can take over an agenda or decision-making process for the disadvantage of less powerful stakeholders.

- As a minimum target value, stakeholder engagement should entail public consultation, however, findings from D6.3 show that more innovative NBS interventions occur where stakeholders learn from one another through venues that allow for exchange of views and policy making knowledge and partnership arrangements;
- It is important to design the stakeholder engagement based on the specific purpose of the engagement. Optimal engagement varies with the situation. Inspiration for different formats can e.g., be found in the Engage2020 Action Catalogue. The Action catalogue is an online decision support tool that aims at enabling researchers, policy-makers and others interested to conduct inclusive formats to identify the method best suited for their

specific purpose. The Engage2020 Action Catalogue is an outcome of the Engage2020 project, which is funded by the European Commission.

5 SYNTHESIS ON CROSS - SECTORAL TARGET VALUES

When implementing or designing targets, it is important to be aware of synergies and trade-offs between both targets and potential outcomes. For example, some targets could in principle negatively impact the potential to achieve targets in a different sector (or affect the ability to address a different urban pressure).

The principle of NBS itself embodies the idea of an integrated ambition to address multiple benefits. To plan and design NBS types that can achieve greater functionality across multiple outcomes, we need to understand how different green infrastructure types are able to deliver different services. Green and blue interventions can give multiple solutions not only for individual pressures but in a more comprehensive way. For this reason, a prerequisite is the understanding of the efficiency of green and blue infrastructures in the urban area to deliver services. Based on this knowledge, a synopsis of multi-functional benefits derived from NBS is needed. Empirical considerations from the different ULLs with their different environmental pressures and release requirements must be thought of together.

We can build this understanding from the REGREEN typology (Jones et al. 2022a). Figure 18 shows how different types of NBS can deliver greater multifunctionality across two independent dimensions, the first (on the x axis) illustrates increasing functionality to deliver diverse outcomes across a suite of regulating services (air pollution removal, noise, carbon, etc.) as well as biodiversity. The second dimension (on the y axis) shows the ability of NBS to deliver wellbeing to people, and is to a large extent a function of the degree to which there is public access and the nature of the space – whether it allows quiet contemplation and relaxation, physical exercise, or whether it serves more of a space for social-interaction. Figure 19 shows the corresponding services and functions that these types of NBS provide. The combination of these two strands of information help users to plan and design NBS to meet the ambition of addressing specific pressures in a multi-functional way to achieve maximum co-benefits. Further detail on the potential performance of each type of NBS is provided in Annex 1 of the REGREEN D3.3 (Jones et al. 2022b).

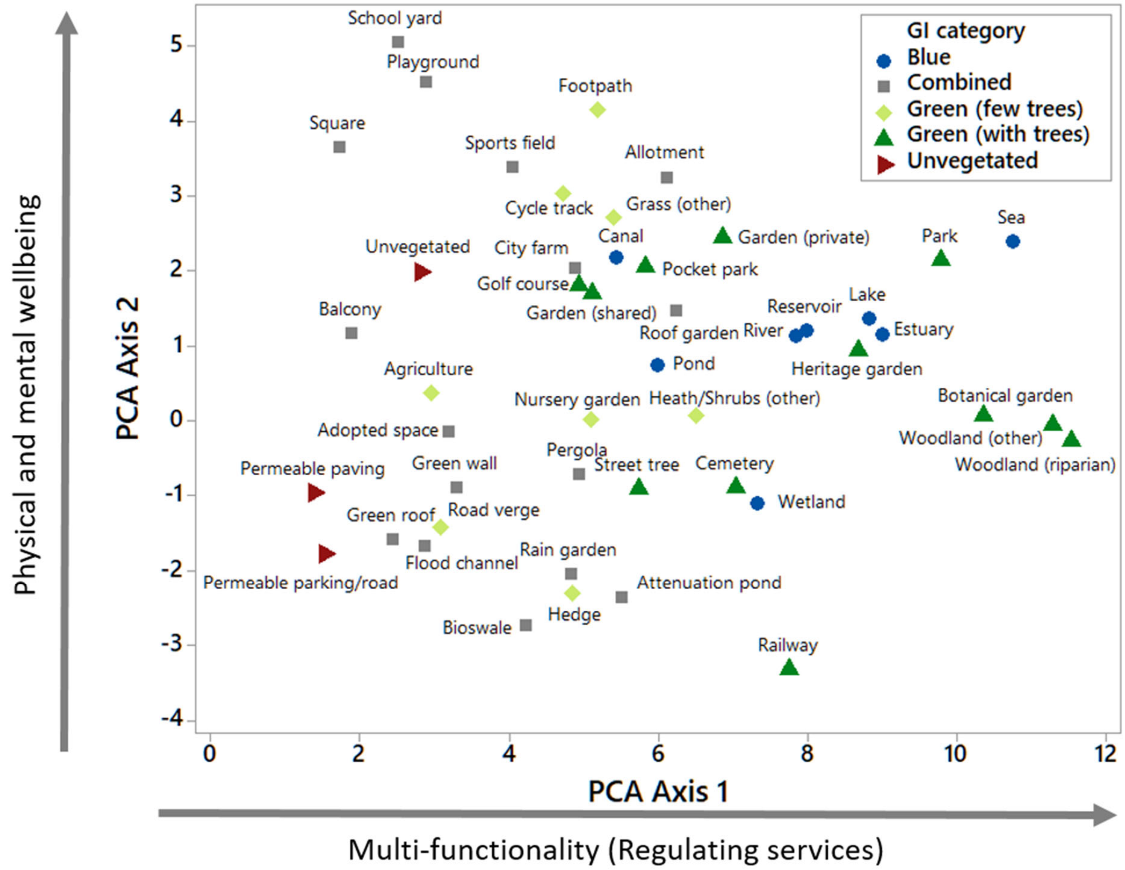

Figure 18 Ability of NBS to deliver ecosystem services, against axes of multifunctionality in regulating services (x) and physical and mental wellbeing (y). Adapted from Jones et al. (2022a)

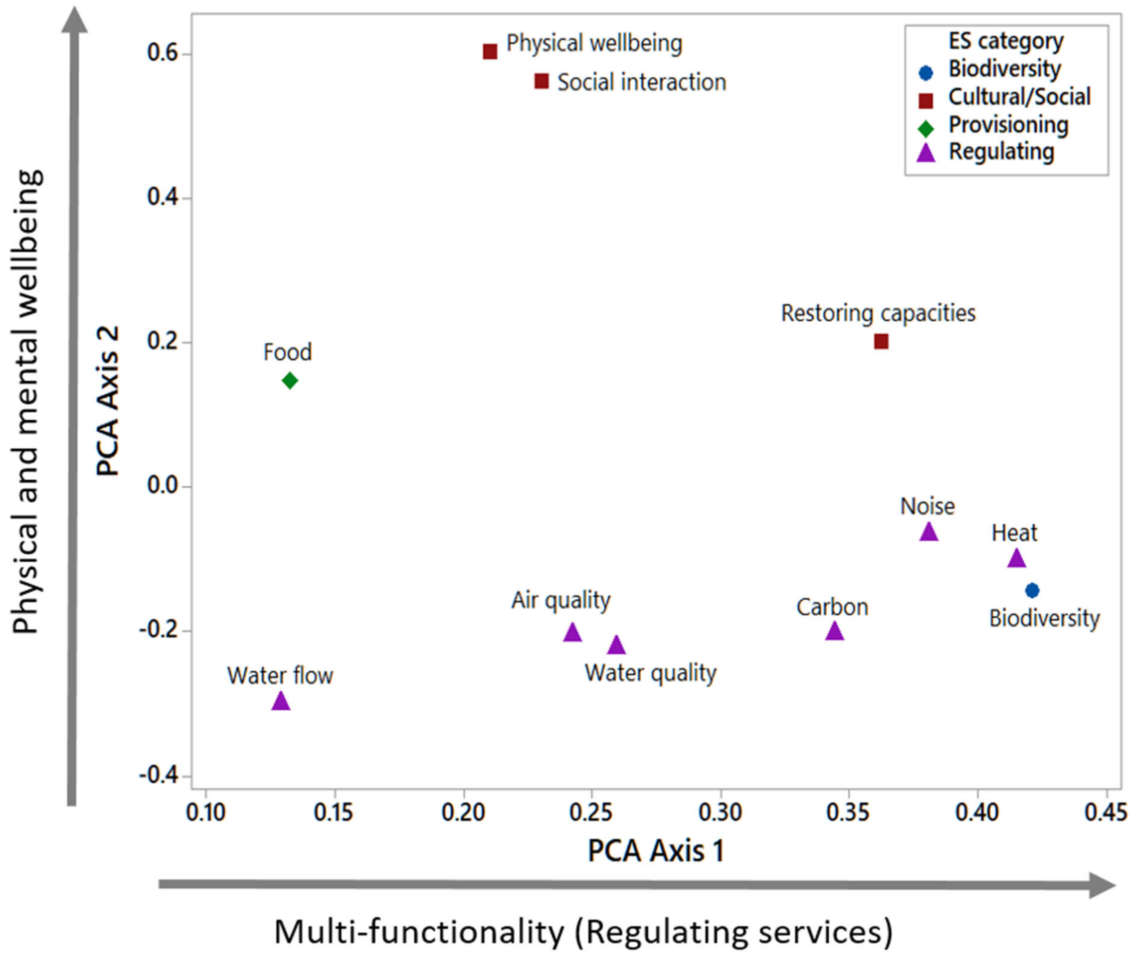

Figure 19 Degree of ecosystem services delivery by NBS, against axes of multifunctionality in regulating services (x) and physical and mental wellbeing (y). Adapted from Jones et al. (2022a)

6 BARRIERS TO ACHIEVE NBS TARGETS

NBS is multifunctional and therefore offers a wide range of benefits in urban environments, helping to address challenges ranging from climate adaptation to social inclusion to health improvements. However, such multifunctionality requires an interdisciplinary approach and collaboration across traditional sector silos such as health, planning, climate, and parks departments; or at the policy agenda level between climate, biodiversity, and economic development. Fragmented and isolated governance arrangements within a community, or lack of coherence between policies at all levels of governance, can impede collaboration, synergy, and joint funding across multiple agendas, creating a barrier to NBS implementation (Pappalardo and La Rosa, 2020, Kirsop-Taylor et al., 2021). Steering green infrastructure depends on respective local to regional policy structures and may suffer from limited cooperation across department boundaries.

A lack of sufficient know-how about which participatory processes work best under which conditions and how to deal constructively with conflicts seems to be an important issue. In the case of the municipality of Aarhus, the experience of very open engagement processes inviting ideas and wishes from the public to implement NBS led to public disappointment when their wishes were not realized either due to budgetary constraints or nonsensical ideas. As a result, the community is now pursuing a much more limited participatory process than before but is still searching for the ideal participatory approach.

Budget constraints can stop the implementation of otherwise good visions and plans to increase resilience through NBS. The way budgets are allocated among city departments can also make or break good NBS implementation. The overall limitations of municipal budgets have increased the need to develop alternative and complementary funding streams and business models to improve NBS implementation. In the case of the municipality of Aarhus, NGOs are working closely with the municipality to generate crowdfunding and corporate donations for tree planting. In Grad Velika Gorica, companies donate trees for school forests and local village fire departments act as project developers and implementers to regenerate local nature. The challenge with these set-ups is that municipalities still need to allocate adequate resources for long-term management and for acquiring land for afforestation, for instance. The municipality of Aarhus is currently seeking new ways of involving private actors and other public institutions in co-ownership of land and NBS.

In larger NBS projects, municipalities may depend on private landowners to change land use practices or sell their land for nature regeneration (e.g., wetlands, forests, meadows). In the case of the municipality of Aarhus, eminent domain is not yet an instrument that the political level is willing to use, so voluntary sale of private land is the only option. For a forest close to the city of adequate size, it may therefore take more than 30 years to reach the full extent of the planned forest area.

As described in section 4.7 above, compartmentalisation and the fragmentation of local government into silos have been identified as a major factor that limits and complicates the uptake and implementation of urban NBS and has been ascertained as a problem for dealing with environmental protection efforts more generally in relation to sustainable transitions.

Additionally, NBS is a relatively new ‘policy idea’ which has to be processed through existing 'old’ political structures. This again can constitute a barrier when trying to make NBS enter political agendas (Haas 1992; Daugbjerg & Pedersen 2004).

Petersen et al. (2023, p.34) analyse several enablers and barriers for uptake of innovative NBS policies in Aarhus municipality, Paris Region and Grad Velika Gorica to a varying extent:

Enablers

- Openness to transversal and collaborative working with stakeholders;
- Exposure to and awareness of other NBS projects elsewhere;
- A powerful policy champion / entrepreneur (e.g. within local government) who is able to influence policy and / or implementation;
- External policy drivers having a tangible local impact– e.g. gradual (climate heat effects) or sudden (e.g. flooding event) – as a catalyst for change;
- Coherence of NBS initiative with existing policies and strategy;
  Availability of dedicated long-term funding.

Barriers

- Lack of funding;
- Tensions between different levels of government (and contrasting perspectives);
- Policy silos (but to a varying degree across cases);
- Too little and too much centralisation can both exhibit barriers;
- Large size and complexity of a municipality - geographically, politically and socially – can constitute a barrier for broad NBS;
- Conflicting perspectives among stakeholders;
- Lobbying e.g., from commercial contractors.

7 CONCLUSIONS

The requirement to establish target values to sustain urban development is vital for European cities. Europe is presently the most urbanised continent on the globe, and projections show that 80-90% Europeans will live in cities by the end of this century. Therefore, the question how we can live in cities in a sustainable and resilient way includes how we value nature in cities in the presence and for the future. Therefore, the REGREEN project investigates how to make nature and their related nature-based solutions most beneficial for urban dwellers.

Urban development of land take for urbanisation processes puts extreme pressure on resilience in cities. Resilience in cities comprises not only climate but also social resilience to stabilise liveability in urban areas. To maintain or even increase urban resilience, blue-green infrastructure needs to be established, intensified and expanded. For this reason, target values for green infrastructure and related NBS are in the focus of this document. They demand a level of satisfactory status, or at least findings of a bare minimum.

To propose target values for NBS in cities needs the reflection across disciplines and encompasses cross-sectoral insights from scientists, stakeholders and planners. The understanding of target values varies greatly between globally defined thresholds for environmental pressures, and the more refined needs for target values at the national, regional and especially local scales. Beyond, different endowments exist in different cities which not only the EC proposal for a nature restoration law illustrates but also target values from different front runner cities across Europe. Working out target values sets the reflection on different types of targets as a prerequisite. This report sheds insight into the most relevant types when focussing on regreening cities. Therefore, the proposed typology of targets is associated with different ecosystem services, with environmental pressures, and with spatially related equity in the urban context. Multiple benefits and trade-offs are discussed to deepen the knowledge of dependencies and synergies between types of targets.

Targets are established by organisations, target values on NBS relate to GI which again is steered by policy structures. Policies again demand for recommendations and rely on arguments like multifunctional benefits from NBS to underpin argumentation. For this reason, barriers how to achieve targets on NBS are an important learning which we share in this document. Further interaction and transdisciplinary work must be undertaken to break-up barriers and relieve implementation of urban NBS. To do so, the recommendation of potential target values should aid to foster this interaction.

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