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Defining Natural Habitat Types as Nature-Based Solutions in Urban Planning

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Abstract: This study focuses on solving urban challenges, such as temperature reduction, urban stormwater management, noise reduction, air quality improvement, and CO_2 concentration reduction, and suggests terrestrial and freshwater habitat types (HTs) found in Europe as innovative forms of nature-based solutions (NBSs). Establishing native HTs in various urban environments to solve urban challenges would enhance biodiversity at different levels and integrate this aspect into urban planning. This contribution builds on the recognition that vegetated surfaces are the most versatile NBS for addressing the broadest range of environmental problems in urban areas and on the understanding that the processes running within these green spaces offer the key to socio-ecological improvements of such areas. Employing a narrative literature review, qualitative content analysis, and interdisciplinary expert discussion, this paper defines why and how unaltered native HTs can be implemented as NBSs in the urban environment, indicates potential HTs for specific urban challenges, and presents an approach to the inclusion of HTs as NBSs in spatial planning documents at national, regional, and local levels. The proposed planning approach attributes added value to HTs and, by linking the concepts of NBSs and HTs, integrates them into urban planning.

Keywords: nature-based solutions; habitat types; urban planning; approach setting

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1. Introduction

Since the definition of nature-based solutions (NBSs) by the European Commission (EC) and the International Union for Conservation of Nature (IUCN) [1,2], the concept has not yet been properly integrated into urban planning, although NBSs are of direct relevance to several areas of urban policy [3]. There are many definitions of NBSs, but in this research they are mainly understood as solutions that use natural processes to solve social challenges. From a spatial planning perspective, it is essential to recognise ecosystems that support appropriate natural processes, or elements that mimic these processes, and to appropriately locate them spatially. Beyond the numerous challenges that have already been addressed, the various kinds of NBSs are also seen as tools for the proper maintenance of existing green infrastructure and its operation in combination with established approaches [4]. Natural habitat types (HTs) offer an additional approach that also strengthens biodiversity.

There are many interpretations of NBSs for the purposes of spatial planning and urban development. Goličnik Marušić et al. [5] argued that, according to the NBS concept, it is important to create an integrated network of solutions in the city, such as natural terrain with woody vegetation and retention ponds, the NBSs that address the widest range of issues, but warned that they may often not be suitable for densely built urban patterns due to lack of space. Natural terrain with vegetation is a surface of untransformed terrain overgrown with terrestrial vegetation. This may include tall-growing woody vegetation if no human intervention has been performed for a sufficiently long period of time to allow succession to occur. As an NBS in the urban green system network, it represents the most versatile solution for addressing the highest number of urban challenges. One of the unique processes that occurs there is the infiltration of stormwater into groundwater. Based on these findings and the fact that the EC has included a criterion in the NBS definition ("NBSs must therefore benefit biodiversity and support the delivery of a range of ecosystem services" [6]), the search is on for innovative forms of NBS derived from natural HTs that support biodiversity and can be used in urban masterplans or related documents.

The NBS concept, as understood in the scientific literature to date, emphasises both the role of biodiversity in benefiting people and the importance of implementing NBSs to help increase biodiversity, which is a value in itself. Research projects (e.g., [7–9]) that aim to achieve societal benefits through NBSs usually distinguish NBSs according to the types of green spaces and green infrastructure elements, such as grasslands, pocket parks, natural river channels, green roofs, swales, and the like, and pay much less attention to the actual types of ecosystems that these types of green spaces or green infrastructure elements form. Accordingly, the capacity of the various ecosystems presented by a set of HTs, and thus their biodiversity, is rarely identified, evaluated, and differentiated. This paper confronts a major challenge: incorporating such aspects into spatial planning to address urban challenges.

Habitat type (HT) is a spatial unit and tool for biodiversity assessment at the ecosystem or landscape level that is primarily used by conservation biologists or similar experts for inventories, such as detailed land-use surveys, or to indicate the presence of protected or valuable HTs and communities or species thriving within them. The HT typology for Europe, a classification of Palaearctic habitats [10] according to which European habitat classification [11] and national habitat typologies are prepared (e.g., [12]), is based on native plant species and is hierarchical. To date, there are no scientific publications or planning practices that utilise natural HTs as spatial units beyond nature conservation. Therefore, their potential for urban planning and development purposes remains a challenge. We assume that naturally occurring or native HTs can be implemented as a form of NBS in the urban environment, in the same biogeographical region and similar climates, as they integrate biodiversity and ecosystem processes with the ability to contribute to solving urban challenges. Fahrig et al. [13] argue that small habitat patches with a total area comparable to that of a few larger patches are equally effective, in spite of what is usually claimed by conservationists. Rather, in many cases, they contribute even more to preventing biodiversity loss. This justifies the concept of integrating HTs into urban planning, which would facilitate the establishment of numerous smaller habitat patches. In this respect, we highlight an overlooked value of HTs that goes beyond nature conservation and contributes to the social aspects of the urban environment. Natural HTs in undisturbed environments (e.g., alluvial alder forest, reeds, scree with sparse vegetation) can have many advantages over common green areas in urban environments, such as lawns consisting mostly of mixtures of cultivars from the genus *Festuca* and *Lolium*, which are common in most parts of Europe.

To find suitable natural HTs that can efficiently address specific urban challenges, we focused on five main groups of HTs used in the European nature information system (EUNIS) habitat classification [11]: (C) inland surface waters; (D) mires, bogs, and fens (wetlands); (E) grasslands and lands dominated by forbs, mosses, or lichens; (F) heathland, scrub, and tundra; and (G) woodland, forest, and other wooded land.

Each HT has a specific structure and can be characterised by the processes that take place within it, the function they pursue, and, on this basis, the benefit they bring. Each HT also has specific spatial and environmental requirements that must be met in order to function as an NBS in an urban environment. We can identify their requirements based on their occurrence in the natural environment. Identifying the characteristics of these HTs provides important information for urban planning, in which HTs can be treated as solutions to societal challenges, but the field is still insufficiently explored. Studies dealing with HTs in urban environments have mainly been concerned with their mapping and the distribution of (threatened) species in the city under consideration (e.g., [14,15]) or with creating habitat typologies based on physical and anthropogenic factors for a particular study (e.g., [16]).

The aim of this paper is to explore how native HTs can be defined as NBSs in an urban environment and to determine the key parameters of HTs and their values for urban planning purposes. We focus on five urban challenges that, according to Metzger et al. [17], can be classified into the group of regulating processes that affect the quality of life in an urban environment: (a) temperature reduction, (b) urban stormwater management, (c) noise reduction, (d) air quality improvement, and (e) CO_2 concentration reduction. We have striven to identify which HTs present in the local environments of the continental and alpine biogeographic regions of Europe can be integrated into the spatial plans of central European cities to address at least one of the urban environment challenges. We hypothesise that such HTs can act as NBSs, which can help to optimise the circularity of materials and energy as aspects of the circular economy (e.g., [18]) and improve biodiversity in urban areas.

Accordingly, we pose the following research questions:

1. What aspects and criteria must be considered to define an HT as an NBS?
2. What are the key parameters of HTs as NBSs that are crucial for urban planning, and what are their descriptive and numerical variables in the context of the urban challenges considered?
3. Which HTs, at the highest possible level of the European habitat classification, are suitable for addressing a given urban challenge?

Based on the findings, we propose an approach for the inclusion of HTs as NBSs in urban planning documents.

2. Research Backgrounds

Many tools have been developed to support the spatial planning and design of NBSs in urban environments by providing environmental and spatial data [19], but none integrate native HTs as spatial units. Further, researchers and designers have addressed NBSs from various perspectives, which has led to the development of multiple NBS frameworks (e.g., [5,20,21]), including proposed spatial and technological units. However, consideration of spatial units always depends on the focus or aspect of NBSs. Habitat types are exact spatial units, represented in a map with an area, and, as such, refer to spatial definitions and units in their own way. In order to define HTs as NBSs in spatial planning documents, it is critical to know the minimum amount of vegetation or water area that is required to solve the urban challenge. The existing literature addresses some of these dimensions, but because the effectiveness of NBSs and their influence areas are, to some extent, site-specific and site-dependent, direct recommendations for spatial planning are limited. Individual findings on the effects of NBSs need to be interpreted in the context in which they occur. In the next sections, we summarise current knowledge about the effectiveness of different vegetation types and water bodies in an urban environment to solve urban challenges. The literature review provides us with clear evidence that the function or the structure of this surface, i.e., the range of (plant) species and soil composition, plays a greater role than the size of the surface area. These findings are an argument for further focusing on the effectiveness of different HTs to address the challenges and their ecological requirements in urban environments.

2.1. CO_2 Concentration Reduction for Climate Change Mitigation

Climate change mitigation by vegetation usually refers to CO_2 sinks, i.e., carbon storage and sequestration, but this is quite limited in urban environments due to a number of factors [22], including the context of precisely calculating the net carbon balance of specific green areas and the carbon footprint of individual plots. When treating urban vegetated areas as NBSs, we also need to consider the CO_2 emissions (not only the sinks) generated by, for example, the implementation and maintenance of these areas and the required materials [23]. When analysing the overall contribution of urban green infrastructure to climate change mitigation, the indirect impacts of vegetation should also be considered [24], as these can lead to lower CO_2 emissions through energy savings, e.g., in heating and cooling [25], or stormwater management [26]. According to a rough calculation [22], blue surfaces (36.1 kg carbon/m^2), parks, and semi-natural urban green spaces (32.6 kg carbon/m^2) contribute relatively well to carbon sequestration in urban areas, followed by urban green areas associated with grey infrastructure (28.9 kg carbon/m^2) and community gardens (23.7 kg carbon/m^2). Research on CO_2 reduction by NBSs or different vegetation types in urban environments is scarce and limited. The IUCN has reported that the implementation of NBSs could contribute to carbon removal and emissions reduction. For example, leaving grass residues on the ground after lawnmowing facilitates biomass production and carbon accumulation in the soil, while fertilisation and irrigation also contribute to carbon production [27] instead of being a carbon sink. Some researchers (e.g., [23,28]) have found that while NBS emissions are lower than those of grey infrastructure, many NBSs still act as a net carbon source due to carbon emissions associated with embodied carbon, material production and transportation, construction, operation, and maintenance. Urban CO_2 sinks with adequate (native) vegetation, which requires as little maintenance and resource consumption as possible, should therefore be considered an important co-benefit that these areas provide for other challenges.

2.2. Temperature Reduction

The urban heat island effect has been an issue for many decades [29]. Vegetation reduces the heat load in hot weather through evapotranspiration and shading. It contributes to cooling both via biophysical processes and biochemically through carbon sequestration [30]. Rinner and Hussain [31], who examined intra-urban patterns of urban heat islands, confirmed that average temperatures are significantly higher in built-up areas and lower for green and blue surfaces.

Large parks with an area of more than 10 hectares have the greatest urban cooling effect among green spaces. They reduce temperatures by 1–2 °C and provide a cooling effect up to 350 m from the edge of the park [32]. The locations where thermal discomfort increases most on hot summer days are in densely built-up areas, more specifically in street canyons, i.e., streets surrounded by tall buildings on both sides and exposed to the sun, with negligible horizontal air exchange [33]. Smaller green spaces are therefore also effective at creating a cooling effect and providing thermal comfort to residents. In the model scenario [33], trees (by 10–13%) and green facades (by 5–10%) contributed the most to mitigating heat stress in streets at the pedestrian level, while green roofs had a negligible impact on the street level, in particular in extreme heat conditions or when buildings were 50 m high or taller [34]. According to another scenario, in peri-urban areas with temperate climates and already moderate tree cover, a 5% increase in mature deciduous trees can reduce surface temperatures by 1 °C, while a 5% increase in hedgerows or new trees can reduce surface temperatures by 0.5 °C [35]. The cooling effect of blue and green areas strongly depends on local conditions. However, the lack of research on the effects of the size, shape, composition, and configuration of blue and green space on the cooling effect limits the ability to make specific recommendations for effective planning, design, and management [36].

2.3. Urban Stormwater Management

Water management services must integrate solutions that provide more retention and infiltration of urban stormwater by mimicking natural processes [37]. The inclusion of vegetation is crucial in this regard, as it can influence the rate and volume of stormwater runoff and thus impact safety from local flooding through interception, absorption, infiltration, and evapotranspiration processes. At the same time, vegetation also helps with stormwater purification, reducing the number and content of pollutants in the water (e.g., [38]). Limited research on specific NBSs has drawn conclusions about the performance of specific solutions in a given area, but these cannot be directly translated into recommendations for spatial planning because they address specific spatial elements (e.g., green roofs as elements of green infrastructure) in specific urban patterns and scales and are therefore fragmentary. Zölch et al. [39] found that both trees and green roofs increase water storage capacity and thus reduce surface runoff. However, the main contribution of trees is to increase interception and evapotranspiration, as their infiltration capacity is limited to the network of planting pits. Interception efficiency varies seasonally, depending on the leafiness of plants [40], regardless of their positioning on the ground or on a roof. A study [41] addressing the effect of plant species and plant diversity on the amount of water runoff from a green roof found that the taller the plants were and the greater their shoot and root biomass, the more effective they were at reducing runoff, while species richness had no effect on runoff. Ercolani et al. [42] concluded that green roofs in cities can be considered a valuable strategy for reducing runoff peaks and volume in urban drainage networks and that the approach is more effective for frequent small-scale storms than for infrequent large-scale storms, as shown by other studies (e.g., [40]). Koiv-Vainik et al. [43] reported a list of other NBSs that provide stormwater management: (a) vegetated buffer strips, (b) vegetated swales, and (c) constructed wetlands. In terms of HTs, these aforementioned solutions could be upgraded by implementing specific native or natural habitats, such as (a) riverine scrubs or riparian woodlands, (b) sedge and reedbeds, and (c) permanent and temporary lakes, ponds, and pools.

In general, the capacity of green infrastructure to reduce stormwater runoff depends on its spatial patterns, landscape patterns, other spatial characteristics [44], and wastewater infrastructure characteristics [42].

2.4. Noise Prevention

In urban environments, people are mainly exposed to noise from road and rail traffic. Vegetation acts as a barrier to the direct propagation of sound waves [45,46], reducing noise from the point source, but is less effective than concrete noise barriers [47] and requires more space. Green walls also have the potential to insulate buildings and absorb sound on streets and other public places [48]. Noise abatement in complex urban environments must take into account the characteristics of trees (height and canopy size), not just the number of trees or the total amount of vegetation in an area [49]. The width of the vegetation barrier is more important than the height in reducing road traffic noise, as most noise is generated between 0.5 and 1.5 m above the ground [46]. Samara and Tsitsoni [50] used field measurements to show that mature pine trees reduce noise intensity by 2 dB at 10 m from the roadway and that the sound barrier of an evergreen pine forest without a shrub layer at 60 m from the motorway reduces noise intensity by 6 dB more than grassland vegetation. Other measurements and model calculations have shown that roadside vegetation barriers of hedges or other dense vegetation along roads reduce noise by 4 dB, which corresponds to a reduction in sound energy of about 50%, with high frequency noise (above 4 kHz) being greatly attenuated and low frequency noise (below 100 Hz) being almost absent [46]. Klingberg et al. [51] have shown that foliage reduces noise at traffic frequencies.

2.5. Improving Air Quality

In our study, we focus on the reduction in local PM10 (particulate matter: particles with a diameter of 10 micrometres or less that can remain in the air for an extended period and penetrate the human respiratory system) concentrations by vegetation, which is facilitated by two processes: the prevention of the flow (dispersion) of polluted air and the deposition of these particles on vegetation. The main local sources of PM10 air pollution in urban areas are traffic and small wood biomass combustion plants. The scientific literature on the effectiveness of vegetation in reducing PM10 concentrations focuses mainly on roadside areas. Increased deposition of particulate matter on vegetation often does not result in noticeable reductions in atmospheric PM10 concentrations. However, when vegetation is exposed to relatively low air volumes and ventilation rates are relatively low (e.g., in urban streets), the effects on ground-level air quality can be very large [52].

The efficiency of interception and retention of particles depends on the location (microclimatic conditions) and plant species [45]. Vegetation with a larger surface area, a higher transpiration rate, and a longer leafing period is generally more effective. The connectivity of the green barrier is also important to preventing the flow of polluted air, as it must be as large as possible, without gaps, and able to provide complete coverage from the ground to the top of the canopy [53,54]. Vegetation as a green barrier should be located as close as possible and parallel to the pollution source (e.g., along roads) and perpendicular to the local wind direction [55]. There are important differences between types of urban spaces (e.g., open space and street canyons), particularly in airflow patterns, which must be considered when planning and designing vegetation. Research has shown that a 10 m wide vegetation barrier with dense and tall vegetation in open space reduces the concentration of many pollutants by more than 50% [55]. Roadside green barriers in open spaces should therefore be at least 4 m high and at least 5 m wide, and the most effective barriers reach a width of 10 m or more [54]. Conversely, in street canyons, tall trees have a negative impact on air quality by preventing ventilation, while lower, dense vegetation (hedgerows) generally has a positive effect [55]. In street canyons, even a green barrier of 1 m in height reduces pollutant concentrations significantly (by about 50%) [52]. Therefore, based on the results of measurements of the effectiveness of so-called hedgerows in reducing the exposure of cyclists and pedestrians to traffic-related air pollution, it is recommended by [56] to plant vegetation 1.7 m high along roads in urban areas, while continuous hedgerows with a width of at least 1.5 m and a height of at least 2 m are found to be the most effective [53]. Vertical greening is also an effective NBS for intercepting pollutants in street canyons and contributes to improving air at ground level [52,53], while green roofs have a lower impact on air quality at pedestrian height, and only when located on lower buildings (up to 10 m high) [57].

3. Methodology

The methodology for defining HTs as NBSs in urban environments for spatial planning purposes consists of three parts. First, an argument for placing HTs as NBSs is based on qualitative content analysis of the key documents and scientific papers that introduce NBSs. This section is based on the integration of various aspects and objectives of NBSs, already substantiated in the political and scientific literature, and answers research question one. Second, following a literature review of the efficiency of different vegetation types and water surfaces in urban areas to address urban challenges, the methodological approach defines the key parameters of HTs with values for effectively solving the specific urban challenges and answering research questions one and two. Third, to create an approach for the inclusion of HTs as NBSs in spatial planning acts regarding the addressed urban challenges, we employ expert interdisciplinary discussion.

3.1. Aspects and Criteria for Defining HTs as NBSs

The research method was employed to answer the following question: what aspects and criteria must be considered when defining an element in the space (in our case, HT) as an NBS? Based on the extensive literature review of definitions and interpretations of NBSs, we first closely focused on key documents published after 2015 by the European Commission (EC) [1], which defined NBSs and positioned the EU as a leader in promoting NBSs [58], and publications by The International Union for Conservation of Nature (IUCN) [59] that were, based on eight criteria and twenty-eight indicators, intended to be hands-on tools to enable the translation of the NBS concept into target actions for implementation. Second, we examined scholarly papers addressing NBSs in relation to urban planning (e.g., [5]) and related contexts (e.g., [3,20,21,60]). Finally, we conducted in-depth analyses of scientific papers related to the principles of NBSs for urban environments [61,62].

Following qualitative content analysis of the literature review, we grouped the collected information according to the meaning and classified it with regard to two aspects: (a) main characteristics that HTs as NBSs can achieve by themselves, called HT aspects, and (b) main characteristics and principles of the NBS concept that can only be achieved with appropriate spatial planning, including management and implementation, called urban planning aspects. Further, after interdisciplinary discussion involving experts from the fields of vegetation and plant ecology, urban planning, geography, and landscape architecture, we provided a rationale to introduce HTs as NBSs. The results following this methodological approach are presented in Tables 1 and 2.

Table 1. HT aspects.

	Aspects and Criteria of NBSs, Which Depend Directly on the Characteristics of a Particular Solution	**Characteristics of HTs with Which the Aspects and Criteria of NBSs Can Be Achieved**
1	NBSs are solution-oriented, effectively address societal challenges, and are simultaneously multifunctional and multi-beneficial.	Some HTs provide the necessary ecosystem processes to address urban challenges, e.g., water retention, ambient cooling, and noise containment. At the same time, they can contribute to other benefits, e.g., providing recreational areas and educational facilities and contributing to a more aesthetically pleasing environment.
2	NBSs are sustainable, resilient to disturbances, energy- and resource-efficient, and mainstreamed within an appropriate jurisdictional context.	Native HTs do not require (much) maintenance (e.g., watering), are self-sustaining, and are more resistant to pests, weather and climate conditions, and other disturbances than HTs of non-native species, unlike agricultural and urban HTs.
3	NBSs are adapted to local and place-based conditions and consider local context.	HTs that thrive in a particular climate zone do so due to adaptation by the dominating plant species that characterise specific HTs.
4	NBSs use nature's features and complex system processes and involve innovative applications of knowledge about nature.	Understanding the functional role of natural processes in HTs, e.g., water retention, air temperature reduction, and noise containment, inspires innovative uses of HTs to address societal challenges.
5	NBSs maintain and enhance natural capital, resulting in a net gain in biodiversity and ecosystem integrity, restoring degraded ecosystems, and therefore benefiting people and biodiversity.	Native HTs contribute to the biodiversity of native species.
6	NBSs are economically viable, cost-effective alternatives to grey or technological-based infrastructure and inclusive solutions for the long term.	Due to their self-sustainability and adaptability to local conditions, HTs can represent an alternative to grey solutions, especially considering their multi-functionality.
7	Nature, the foundation of any NBS, may take many forms; therefore, NBSs include natural, artificial, and hybrid solutions which vary in scope, scale, and range of function.	An HT that is implemented in a specific micro-location in an urban environment to address a particular challenge must often be constructed anew. In this case, the HT is a reconstruction of an HT from the natural environment and is an "artificial or hybrid nature-based solution", as it requires specific implementation interventions, such as the establishment of appropriate site conditions.

Table 2. Urban planning aspects.

	Aspects and Criteria of NBSs That Depend on Proper Spatial Planning and Management	How to Plan, Manage, and Implement HTs to Achieve Aspects and Criteria
1	NBSs enhance sustainable urbanisation through climate change adaptation and mitigation, improving risk management and resilience, and supporting mutual learning for city sustainability transitions.	HTs could be maintained and constructed in urban environments to address the challenges of adapting to climate change and building resilience to contribute to sustainable urbanisation.
2	NBSs are planned, implemented, and managed by an integrative and holistic approach with various stakeholders, connecting disciplines and sectors, involving innovative governance and institutional, business, and finance models and frameworks.	Implementing HTs in an urban environment requires interdisciplinary cooperation between experts, such as biologists, spatial planners, and those in disciplines related to the urban challenges at hand. It also requires the cooperation of different departments, e.g., the city's environmental protection, communal department, urban planning, and investment. All of this requires new approaches to cooperation.
3	NBSs are managed adaptively, based on evidence, aligned with the socio-ecological and institutional context, and designed to scale with the need for a systemic understanding.	The implementation or protection of HTs as NBSs should be based on knowledge of the local site conditions and, on a broader scale, consideration of both environmental (e.g., micro-climate, growing conditions) and social factors (e.g., population structure, activities in the area, values of the inhabitants), and it should be planned based on expert evidence.
4	NBSs provide business opportunity.	The introduction of a specific HT as an innovative NBS provides an opportunity for the private sector (companies) to specialise in the design and implementation of such solutions.
5	NBSs are based on inclusive, transparent, empowering, and integrated governance processes.	Inclusive, transparent planning is essential for the widespread acceptance and effective operation of innovative solutions (such as HTs) in urban areas. This might include involving local people and managing in a way that integrates HT maintenance into existing urban management practices.
6	NBSs equitably balance trade-offs between achievement of their primary goal(s) and the continued provision of multiple co-benefits.	HTs as NBSs are primarily located or protected to address a specific challenge (e.g., water retention in urban flooding, air cooling, noise prevention), but it is necessary to ensure that these areas also provide other functions, such as recreational use and education. A multi-criteria evaluation and comparison of these solutions against other alternatives is needed in the planning process.

3.2. Defining Key Basic Urban Planning-Related Parameters and Their Values

Assuming urban planning to be a means for provision of sustainable development and quality living environments, we defined three basic urban planning–related parameters considering size and shape of HTs and the typology of the urban environment: (a) minimum surface of HTs to efficiently address the targeted urban challenge, (b) urban environment components suitable to place HTs, and (c) adequate floor plan or vertical plan appearance of HTs for targeted urban challenges.

To define descriptive and numerical variables and their values for these parameters of HTs, we employed the narrative literature review method. This method summarises key works selected by the authors, developing ideas from other studies [63] and linking them to our research. As individual HTs, to date, have not been studied regarding their efficiency in solving the selected societal challenges in urban environments, we built the identified parameter values on scientific studies that addressed vegetation and water surfaces in general to answer the following question: what is known about the effectiveness of different vegetation types, water surfaces, and their areas in the urban environment to address the target urban challenges? Supported by the aspects and criteria that define HTs as NBSs (characteristics of a particular solution, proper spatial planning, and management), we defined the square meter (m^2) as the numerical variable for the parameter of the minimum surface of HTs and as descriptive variables for the parameters of urban environment components and the floor plans of HTs. Hence, although various projects, such as Naturvation, UNaLab, Nature4Cities, and GrowGreen, produce compendiums and handbooks that include the technical aspects for selected types of NBSs (e.g., vertical green, swale), the concrete HTs related to such types of NBSs have not yet been studied in detail. Therefore, the technical aspects of NBSs correlated with specific HTs are not available. Thus, this study is limited to the mentioned urban planning-related aspects that can, given the available knowledge, be adequately considered.

Value determination of the variables for the three basic parameters and general ecological knowledge about HTs allowed us to use a selection process to determine five of the highest levels of terrestrial and freshwater HTs (inland surface waters; wetlands; grasslands and lands dominated by forbs, mosses, heathland, and scrub; forest; and other wooded land) as defined for Europe by the European nature information system (EUNIS) [10,11,64]. Within these highest levels, corresponding suitable lower-level HTs can be found to address specific urban challenges. We excluded marine (group A) and coastal (group B) HTs, as we limited the focus to urban issues of the inland regions, which are mainly the result of inappropriate urban planning that neglects the importance of blue/green surfaces in cities or even replaces them with paved and built-up areas. We also excluded HTs from groups I and J of the EUNIS habitat classification (I: regularly or recently cultivated agricultural, horticultural, or domestic habitats; J: constructed, industrial, and other artificial HTs, such as buildings, transport networks, waste disposal sites, etc.). These are not target HTs because they host almost no plants or animals.

4. Results

The presentation of the results follows the methodological workflow with the aim of explaining how to incorporate HTs as NBSs in spatial planning. We present the following findings:

1. Characteristics of HTs; planning, management, and implementation of HTs that match NBS aspects and criteria and therefore support the decision by urban planners to use HTs as a form of NBS to address specific urban challenges, such as urban heat islands or stormwater flooding.
2. Parameters of HTs; their variables and values related to urban challenges for use in cartographic representation of various scales relevant to urban planning.
3. Determination of potential HTs for a specific challenge, given the parameter values.

4.1. The Rationale for Introducing HTs as NBSs

Aspects and criteria to define HTs as NBSs are introduced in Tables 1 and 2. Table 1 focuses on HTs as elements in the space with their own characteristics (HT aspects). Table 2 focuses on the aspects of planning, implementation, and management of HTs in urban environments (urban planning aspects). The former aspects are defined by characteristics of NBSs, which are generally described as driven by nature, solution-oriented, multi-beneficial, sustainable, resilient, energy- and resource-efficient, locally specific, beneficial to biodiversity, and cost-effective. Table 1 shows that all of these characteristics can be attributed to an individual HT placed in a space to solve a specific urban challenge, which can therefore be defined as an NBS.

The urban planning aspects shown in Table 2 relate to the sustainability of solutions, the use of an interdisciplinary, systemic, and holistic approach, the provision of multiple co-benefits, and any business opportunities related to the introduction of NBSs. These aspects do not depend on HTs per se, but on how we plan and manage them, and they are therefore important for the appropriate planning of the use of NBSs and their distribution in urban environments.

4.2. Parameters of HTs as NBSs for Urban Planning Purposes

Urban planning-related parameters of HTs (minimum surface of HTs, urban environment components where HTs can be placed, and floor/vertical plan appearance of HTs) and their variables and values, which vary depending on the urban challenge, are presented in Table 3.

Table 3. Parameters of HTs as NBSs and values related to urban challenges with the determination of potential HTs according to EUNIS classification. Back colors represent different urban challenges: yellow—temperature reduction, blue—urban stormwater management, orange—noise prevention, grey—air quality improvement.

Urban Challenge	Urban Planning-Related Parameters			Potential HTs of the Highest Hierarchical Level of EUNIS Habitat Classification					Examples of HTs on Lower Hierarchical Levels of EUNIS that Function as NBSs
	Min. Area of HT	**Urban Environment Components**	**Plan Appearance**	**C Inland Waters**	**D Wetlands**	**E Grasslands**	**F Scrubs**	**G Woodlands**	
Temperature reduction	1 m^2	Impermeable ground areas	line, surface	no	no	No	yes	yes	G5.1 Lines of trees
		Vegetated areas	line, surface	yes	yes	yes	yes	yes	G1 broadleaved deciduous woodland; G3 coniferous woodland; G4 mixed woodland C1.1 and C1.2 permanent oligotrophic and mesotrophic lakes, ponds, and pools; C3.2 water-fringing reedbeds and tall helophytes other than canes
		Green roofs	line, surface	no	yes	yes	yes	yes	D1.1 raised bogs; E1.1 inland sand and rock with open vegetation; F2.4 conifer scrub; F3.1 temperate thickets and scrub; FA.3 species-rich hedgerows of native species; G3.4 *Pinus sylvestris* woodland; G3.5 *Pinus nigra* woodland
		Vertical greenings	vertical surface	no	no	yes	yes	no	F2.4 conifer scrub; F3.1 temperate thickets and scrub; F6 garrigue; FA.3 species-rich hedgerows of native species; G3.5 *Pinus nigra* stands
Urban stormwater management	1 m^2	Impermeable ground areas	line	yes	yes	yes	yes	yes	C1.1 and C1.2 permanent oligotrophic and mesotrophic lakes, ponds, and pools; C1.6 temporary lakes, ponds, and pools; C3 littoral zone of inland surface waterbodies (C3.1, C3.2, C3.5); D5 sedge and reedbeds, normally without freestanding water (D5.1, D5.2, D5.3); E3 seasonally wet and wet grasslands; F9.1 riverine scrub; G1.1 riparian woodland, with dominant *Alnus*, *Populus*, or *Salix*
		Vegetated areas	line, surface	yes	yes	yes	yes	yes	G1 broadleaved deciduous woodland; G3 coniferous woodland; G4 mixed woodland
		Green roofs	line, surface	no	yes	no	yes	no	D1.1 raised bogs; F2.4 conifer scrub; F3.1 temperate thickets and scrub; FA.3 species-rich hedgerows of native species; G3.4 *Pinus sylvestris* woodland; G3.5 *Pinus nigra* woodland

Table 3. *Cont.*

Urban Challenge	Urban Planning-Related Parameters			Potential HTs of the Highest Hierarchical Level of EUNIS Habitat Classification					Examples of HTs on Lower Hierarchical Levels of EUNIS that Function as NBSs
	Min. Area of HT	Urban Environment Components	Plan Appearance	C Inland Waters	D Wetlands	E Grasslands	F Scrubs	G Woodlands	
Noise prevention	5 m^2	Impermeable ground areas	line	no	no	no	yes	yes	F2.4 conifer scrub; F3.1 temperate thickets and scrub; G2.6 *Ilex aquifolium* woods; G3 coniferous woodland, such as G3.2 alpine *Pinus cembra* woodland, G3.5 *Pinus nigra* woodland, and G3.9 coniferous woodland dominated by Cupressaceae or Taxaceae
		Vegetated areas	line, surface	no	no	no	yes	yes	G3 coniferous woodland; G4 mixed woodland
		Vertical greenings	vertical surface	no	no	no	yes	no	F2.4 conifer scrub; F3.1 temperate thickets and scrub; F6 garrigue; G3.5 *Pinus nigra* stands
Air quality improvement	1 m^2	Impermeable ground areas	line	no	no	no	yes	yes	F2.4 conifer scrub; F3.1 temperate thickets and scrub; FA.3 species-rich hedgerows of native species; G2.6 *Ilex aquifolium* woods; G3.2 alpine *Pinus cembra* woodland; G3.5 *Pinus nigra* woodland; G3.9 coniferous woodland dominated by Cupressaceae or Taxaceae
		Vegetated areas	line, surface	no	no	no	yes	yes	C3.2 water-fringing reedbeds and tall helophytes; F2.4 conifer scrub; F3.1 temperate thickets and scrub; FA.3 species-rich hedgerows of native species; G2.6 *Ilex aquifolium* woods; G3.2 alpine *Pinus cembra* woodland; G3.5 *Pinus nigra* woodland; G3.9 coniferous woodland dominated by Cupressaceae or Taxaceae; G4 mixed woodland
		Vertical greenings	vertical surface	no	no	no	yes	no	F2.4 conifer scrub; F3.1 temperate thickets and scrub

The minimum surface of HTs was defined as the minimum necessary vegetation or water area in the urban environment in which an HT can be located to contribute efficiently to the targeted urban challenge. Considering the specificities of urban space, the challenges addressed, and the effectiveness of vegetation and water areas to address these challenges, HTs as NBSs should be considered in HT polygon sizes of at least (a) 1 m^2 for the challenges of temperature reduction, urban stormwater management, and air quality improvement and (b) 5 m^2 for noise prevention. Consideration of CO_2 mitigation by HTs was excluded due to the larger areas required and the reverse effect (e.g., CO_2 production in the case of green roof or vertical greening); accordingly, HT implementation for the sole purpose of a carbon sink does not make sense.

Structurally, urban environments generally consist of paved surfaces (e.g., roads, squares), buildings, and green areas with vegetation or water bodies. To illustrate the possible use of HTs in the urban environment to address the considered urban challenges, four components on which HTs can be placed were identified (see also Table 3).

1. Impermeable ground areas: built surfaces that are not in a natural state because they are sealed by man-made elements or materials (e.g., paved, asphalted), have no or significantly reduced water infiltration capacity, and are not covered by buildings or ancillary structures. Such areas also include planting pits with limited expansion possibilities, such as plantings in squares and streets, as well as areas right next to roads and buildings, where planting is limited due to underground infrastructure.
2. Vegetated areas: green areas that have contact with the geological subsoil and thus can retain and sink water, allowing tall plants with deep roots to grow and organisms to live in and above the soil. These also include bodies of water (ponds, rivers, lakes, etc.).

3. Green roofs: properly constructed and prepared roofs of buildings or other built structures that are covered with vegetation.
4. Vertical greenings: vegetated external walls of buildings or other structures.

The floor plan appearance of the HT is a parameter we introduced which represents a polygon of vegetation or water surface (or vertical plan, in the case of vertical greenings). It refers to a two-dimensional presentation on a map to effectively address a particular challenge. The floor/vertical plan appearance may be a surface or line in a horizontal or vertical position.

Table 3 illustrates how some native HTs, as a source of natural (domestic) biotic material, can be used as NBSs for temperature reduction, urban stormwater management, noise prevention, and air quality improvement on the four most typical types of surfaces that can involve vegetation in urban areas. The following sections comment on the suitability of such HTs regarding each urban challenge.

4.3. Potential HTs for Temperature Reduction

For heat island mitigation, any green or blue surface will cause a reduction in surface temperature, so any siting of HTs in the urban environment on or adjacent to existing hard surfaces is relevant. Given that the denser and taller the vegetation, the greater its cooling effect, vegetated areas are especially suitable for implementing HTs. These may be remnants of natural vegetation or newly created. Remnants of forests would significantly contribute to reductions in air temperature, regardless of their type, which depends on the region and altitude. Any attempt to preserve these habitats, such as G1 broadleaved deciduous woodland, G3 coniferous woodland, and G4 mixed woodland (lower level of HT classification, depending on the region), from destruction is critical to solving this challenge. All types of permanent surface waters are also efficient at temperature reduction due to the evaporation of water from the surface of the waterbodies as well as the evapotranspiration of reeds and other tall helophytes: C1.1 and C1.2 permanent oligotrophic and mesotrophic lakes, ponds, and pools; C3 littoral zone of inland surface waterbodies, in particular C3.2 water-fringing reedbeds (*Phragmites australis*) (Figure 1) and tall helophytes (*Typha latifolia*, *Schoenoplectus* spp.) other than canes.

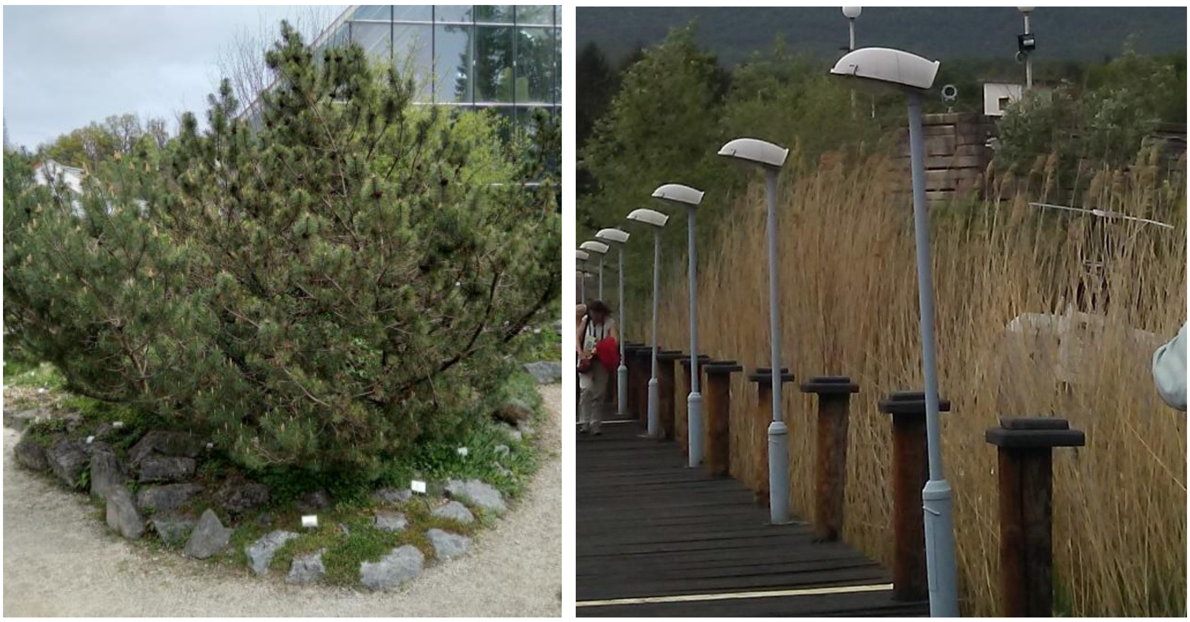

Figure 1. HTs as NBSs addressing several environmental challenges: F2.4 conifer scrub—bushes/stands with *Pinus mugo* (**left**) and C3.2 water-fringing reedbeds—*Phragmites australis* (**right**).

For impermeable ground areas, the most suitable HTs proved to be forests and other wooded land, as they also provide shading. Newly constructed and planted strips or small patches of woodlands in areas such as car parks are recommended (G5.1 lines of trees).

One green roof, especially on a tall building, has no impact on temperature reduction at pedestrian levels, but a more expansive green roof system has an impact on reducing the urban heat island, so planting HTs on structurally adequate flat roofs could play a significant role. For this purpose, HTs that require no or minimal care (e.g., watering, mowing) after their construction on the roof are preferred, such as D1.1 raised bogs, which are fed exclusively by precipitation in nature; grasslands and lands dominated by forbs, mosses, etc. (E1.1 inland sand and rock with open vegetation—mostly annuals and succulents such as *Sedum* spp.); scrubs (F2.4 conifer scrub: bushes/stands with *Pinus mugo*); F3.1 temperate thickets and scrub; FA.3 species-rich hedgerows of native species; and woodlands (G3.4 *Pinus sylvestris* woodland; G3.5 *Pinus nigra* woodland).

For vertical greening, effectiveness in temperature reduction depends on the position of the planting (on the building and in the street) and on orientation and exposure. Planting stands or fragments of HTs that tolerate low quantities of water but still have sufficient biomass to support evapotranspiration can be helpful, such as scrubs on the walls of buildings (F2.4 conifer scrub: bushes/stands with *Pinus mugo*; F3.1 temperate thickets and scrub; F6 garrigue; FA.3 species-rich hedgerows of native species) and woodlands on "balconies" (see Figure 2).

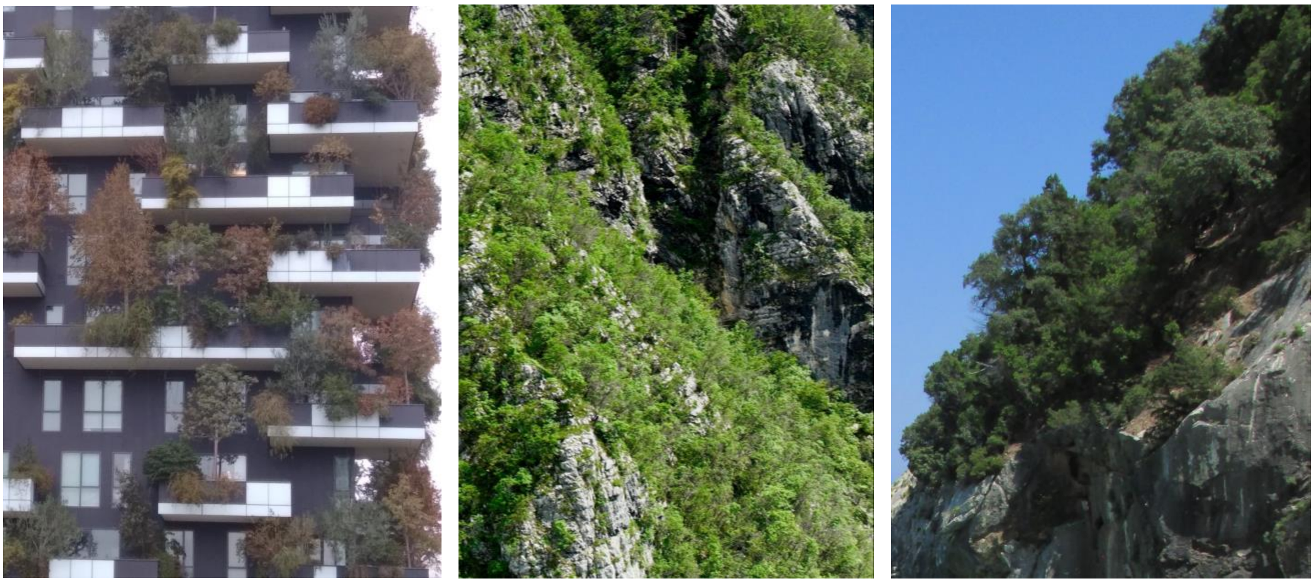

Figure 2. Examples of HT fragments (from **left**): woodland on "balconies" in Milan and native HTs on very steep limestone slopes (**middle**: F3.1 temperate thickets and scrub; **right**: F6 garrigue).

4.4. Potential HTs for Urban Stormwater Management

As with temperature reduction, any green or blue surface implementation helps to address urban stormwater management, as any HTs with enough capacity for water retention and/or infiltration reduce or delay surface runoff and so mitigate peak flows and volumes in urban drainage networks. Vegetation also contributes to water purification. The more layered the green surface (herb, shrub, and tree layers), the more it can reduce or delay surface runoff. In this respect, the most efficient are HTs such as G1 broadleaved deciduous woodland, G3 coniferous woodland, or G4 mixed woodland, depending on the region.

Newly constructed and planted concave strips or patches of HTs are relevant, especially on and near impermeable ground areas, respectively, where HTs from all higher hierarchical levels are potentially efficient: surface waters (C1.1 and C1.2 permanent oligotrophic and mesotrophic lakes, ponds, and pools). It is important to provide HTs which are "dry" most of the year but can be temporarily flooded; these act as significant recipients of stormwater when necessary, as huge amounts of water can run off paved/built-up surfaces during heavy rains: C1.6 temporary lakes, ponds, and pools; C3 littoral zone of inland surface waterbodies (C3.1, C3.2, C3.5); D5 sedge and reedbeds, normally without free-standing water (D5.1, D5.2, D5.3); E3 seasonally wet and wet grasslands; F9 riverine and fen scrubs (F9.1 riverine scrub with *Salix* spp., *Alnus* spp., and *Myricaria germanica*); and G1.1 riparian and gallery woodland with dominant *Alnus, Betula, Populus*, or *Salix*.

Planting HTs on structurally adequate flat green roofs can have an impact on reducing peak flows and volumes in urban drainage networks during frequent small-scale storms by retaining large amounts of water: D1.1 raised bogs can both act as a sponge after a dry period and tolerate long periods under water. Similar functions are performed by F2.4 conifer scrub (bushes/stands with *Pinus mugo*), G3.4 *Pinus sylvestris* woodland, F3.1 temperate thickets and scrub (*Juniperus communis* formations), FA.3 species-rich hedgerows of native species, and G3.5 *Pinus nigra* woodland, which contribute to water retention but demand sufficient drainage.

Implementing vertical greening HTs to address urban stormwater management has no noteworthy effect.

4.5. Potential HTs for Noise Reduction

For noise reduction, water surfaces, including HTs of inland surface water and wetlands, are not suitable for implementation in any urban environment components. For impermeable ground areas along traffic routes, suitable HTs should include a vegetation barrier at least 1.5 m wide and 2–3 m high, ideally 5 m wide and as dense as possible. Obviously, this type of vegetation strip is not a sensible measure along narrow streets. To enhance their function all year round, it is also important to select HTs in which evergreen woody plants species dominate, such as F2.4 conifer scrub (bushes/stands with *Pinus mugo*), F3.1 temperate thickets and scrub (*Juniperus communis* formations), G2.6 *Ilex aquifolium* woods (stands of *Ilex aquifolium* and *Taxus baccata* in shady sites), and G3 coniferous woodland (e.g., G3.2 alpine *Pinus cembra* woodland, G3.5 *Pinus nigra* woodland, and G3.9 coniferous woodland dominated by Cupressaceae or Taxaceae).

For a greater impact at the street level, green walls can be created on several buildings and structures facing the street to absorb sound and soundproof the buildings: F2.4 conifer scrub (bushes/stands with *Pinus mugo*), F3.1 temperate thickets and scrub (*Juniperus communis* formations), F6 garrigue, and woodlands on "balconies", specifically G3.5 *Pinus nigra* stands.

Vegetated areas along thoroughfares surrounded by large flat areas, e.g., along motorways outside densely built-up regions, are particularly suitable for planting scrub and woodland HTs. Alternatives include F2.4 conifer scrub (bushes/stands with *Pinus mugo* (Figure 1)), F3.1 temperate thickets and scrub (*Juniperus communis* formations), and G3 coniferous woodland or G4 mixed woodland (lower level of HT depending on the region).

4.6. Potential HTs for Air Quality Improvement

For air quality improvement, HTs of inland surface water and wetlands have no significant impact, except stands of reeds and tall helophytes. Larger HTs with species that have leaves and thus a higher transpiration rate and longer periods of foliage are more effective: C3 littoral zone of inland surface waterbodies, in particular C3.2 water-fringing reedbeds (*Phragmites australis*) and tall helophytes (*Typha latifolia*, *Schoenoplectus* spp.); F2.4 conifer scrub (bushes/stands with *Pinus mugo* (Figure 1)); F3.1 temperate thickets and scrub (*Juniperus communis* formations); FA.3 species-rich hedgerows of native species; G2.6 *Ilex aquifolium* woods (stands of *Ilex aquifolium* and *Taxus baccata* in shady sites); G3 coniferous woodland, such as G3.2 alpine *Pinus cembra* woodland, G3.5 *Pinus nigra* woodland, and G3.9 coniferous woodland dominated by Cupressaceae or Taxaceae; and G4 mixed woodland (lower level of HT depending on the region).

The efficiency of interception and retention of particles depends on the location details (mainly wind direction and spatial morphology) and is therefore highly site-specific. In street canyons, continuous hedges with a minimum width of 1.5 m and a minimum height of 2 m are the most effective at the pedestrian level, while taller plants can exacerbate the issue by blocking airflow. Newly constructed and planted HTs, therefore, must be located near sources of pollution, e.g., traffic routes, industrial zones, or areas to be protected (e.g., residential, recreational) and consider local ventilation specifics. Possibilities include F2.4 conifer scrub (bushes/stands with *Pinus mugo*), F3.1 temperate thickets and scrub (*Juniperus communis* formations), FA.3 species-rich hedgerows of native species, G2.6 *Ilex aquifolium* woods (stands of *Ilex aquifolium* and *Taxus baccata* in shady sites), and G3 coniferous woodland, such as G3.2 alpine *Pinus cembra* woodland, G3.5 *Pinus nigra* woodland, and G3.9 coniferous woodland dominated by Cupressaceae or Taxaceae.

To increase the particle deposition effect in street canyons, green walls should be created on several buildings in heavy-traffic streets by utilising F2.4 conifer scrub (bushes/stands with *Pinus mugo*) and F3.1 temperate thickets and scrub (*Juniperus communis* formations).

5. Discussion

5.1. Application of HTs as NBSs in Urban Planning

Considering the determination of potential HTs for each challenge, we elaborate on the following key findings:

- HTs of inland surface waters are unsuitable for implementation on green roofs due to the limitations of building construction. They are suitable for implementation on vegetated and impermeable areas to address temperature reduction and urban stormwater management; for the latter, line implementation on impermeable ground areas is generally sufficient.
- Wetland HTs are suitable for implementation on green roofs and vegetated areas for temperature reduction and urban stormwater management. For the latter challenge, these are also suitable for line implementation on and near impermeable ground areas.
- Grasslands and lands dominated by forbs, mosses, and scrub are suitable for addressing all four challenges and all urban environment components.
- Forest and other woodland HTs are suitable for implementation as vertical greenings and on roofs to a limited extent, due to construction requirements. They have proven to be the most effective for all four challenges, which they solve simultaneously via multi-purpose and multi-beneficial characteristics.

Based on the defined aspects and criteria of NBSs and the values of parameters of HTs as NBSs, this paper further considers the practical implications of HTs as NBSs in urban planning through examination of their inclusion in spatial planning acts at different levels and scales (Table 4). As countries around the world have different planning systems and required scales for various planning levels, we have classified spatial planning acts into three main groups according to general scale: national, regional, and local. For the integration of HTs as NBSs into existing spatial planning practices, it is essential to evaluate both spatial implementation and strategic levels of planning. In strategic spatial acts, there is an opportunity to define the NBSs as a way to solve the discussed challenges, while in executive spatial acts, NBSs can be graphically displayed. Spatial acts at the local (municipal) level are the most relevant for using HTs as NBSs to solve urban challenges.

Table 4. Proposal for inclusion of HTs in spatial planning documents at national, regional, and local levels.

Spatial Planning Level	Spatial Scale	Findings
State/national spatial plans	Whole country	The scale of the national spatial planning level is too small to locate HTs in urban environments, and it is not possible to include HTs in graphical representations of state spatial plans. However, strategic guidelines with national spatial development objectives are important, as they provide general principles or incentives for the implementation of such solutions in the local area. Individual HTs in urban areas should be understood in national strategies as smaller spatial units (polygons) than green and blue areas or as their individual elements that also occur within other areas, e.g., residential. This is because green areas, as spatial information, do not provide data on their functionality; green spaces should be further broken down regarding suitable HTs for urban challenges.
Regional plans	Region, usually 1:250,000	At the regional planning level, the spatial scale is still too small to show in a graphical form the positioning of specific HTs to address urban challenges. NBSs as a way to address urban challenges could be given as a guideline in the descriptive section of the planning document. Defining specific HTs at the regional level makes sense for urban challenges, the impact of which cross municipal boundaries, or challenges which need to be addressed at the inter-municipal level (e.g., river flooding, urban agglomeration cooling). Regional plans need to provide space for HTs as a solution to such challenges by mapping, and their positioning should be directly mapped into spatial planning acts at the local level.
City plans, master plans, and detailed master plans	City and parts of the city, usually 1:5000	HTs as NBSs can be defined and mapped as: - new HT siting/implementation to avoid negative impacts or urban challenges caused by planned or already implemented development, - existing HTs to protect already functioning NBSs (e.g., riparian, forest, wetland) in the same way as HTs that are important for nature conservation. In urban master plans, the assessment of the situation and future needs/uses of the area identify urban challenges that can be addressed by NBSs and propose solutions in the technical bases by locating or protecting appropriate HTs at a scale of at least 1:5000. It is important that the construction or protection of HTs is properly defined in any spatial implementation conditions, as these directly condition the planning of spatial interventions. In a specific spatial planning unit, HTs and their uses (accessibility, types of recreation, etc.) should be defined, including protection regimes, specific restrictions, and requirements. Within the framework of these provisions, there is also an opportunity to understand and predict the occurrence of HTs on green roofs and vertical greening types of surfaces.

To summarise, this paper outlines an approach towards the inclusion of HTs as NBSs in spatial planning acts and their implementation in the urban environment, suggesting a five-level workflow:

1. To recognise and define specific local urban challenges and areas of intervention.
2. To decide on the NBS concept as a way of addressing challenges.
3. To decide on HTs as a form of NBS (based on Tables 1 and 2).
4. To look for suitable native HTs for urban challenges (based on Table 3).
5. To include HTs in spatial planning acts (based on Table 4).

There are no legal provisions for NBSs, so spatial planning with NBSs will come into play when decision-makers and planners at all levels recognise their value. As noted by [65], the key conditions for the implementation of NBSs are political support for these approaches, catastrophic events, and, to a lesser extent, the resources without which NBSs cannot be implemented. The needs of cities for planning and implementing NBSs, i.e., those responsible for the municipal spatial planning level, are reflected in the areas of knowledge (systems thinking and solution-oriented thinking to understand NBSs), skills (negotiation and collaboration), and partnerships and collaborative governance to overcome the barriers associated with stand-alone, independent, and disconnected administrations to build multi-sectoral partnerships [66].

The implementation of EU policies is highly dependent on the planning systems of each country, so both spatial plans and long- and medium-term development strategies have an impact on the implementation of NBSs [67]. It is important that NBSs from EU-level documents be translated into national spatial development strategies and related acts of implementation levels. The spatial documents that follow such strategies can be a tool for the integration of NBSs into spatial planning in an integrative and systemic way. As shown in this paper, one of the ways can be the introduction of HTs as NBSs.

Integration of HTs as spatial units in spatial planning involves interdisciplinary approaches, where the planning process requires the collaboration of several disciplines, in particular, urban planning, urban policies, biology, and ecology, on one hand, and, on the other, disciplines dealing with the highlighted urban challenges addressing water, noise, air quality, and urban heat islands. The introduction of these NBSs thus offers the opportunity and necessity for new forms of cooperation and governance, as many studies on NBSs have pointed out, including [65,68,69].

5.2. Limitations of the Approach and Further Research

Our findings confirm that it makes sense to provide further support in the academic and urban planning spheres to integrate HTs as NBSs in urban planning knowledge and practice and to go beyond the sole use of HTs for nature conservation purposes. The approach presented in this paper is based on arguments and facts that deserve further elaboration in the future.

Current knowledge about different NBSs and vegetation/water surfaces, based on which we defined parameters for spatial planning purpose of HTs and their values, rarely addresses the synergistic effects of different types and sizes of vegetation and water bodies, e.g., the effect of vertical greening, parks, green roofs, and trees together. Similarly, the synergistic effects of a given area can address different challenges at the same time (e.g., the importance of aeration for both cooling and air quality; the negligible impact of a green roof on the pedestrian level but the significant impact on the urban heat island in the wider area and the possibility of using green roofs as a walkway), thus contributing to social functions. For spatial planning, it is crucial to address multiple challenges simultaneously in an integrated (rather than in a single-layer) way by linking the effects of different surfaces. Although location is an important aspect in general planning recommendations, it is not only about local specificities but also about how to design and plan a city with other parameters (choice of materials, orientation of buildings, ventilation, etc.) in order to achieve the desired effects.

Examination of the higher levels of HTs for specific urban challenges confirms that vegetation types with more complex structures (trees, shrubs, and herbaceous layers) have a higher capacity to provide ecosystem services in urban environments, such as climate regulation, air purification, carbon sequestration, erosion prevention, water purification, and flood prevention [70,71]. However, for HT implementation on green roofs and green walls, as unique components of the urban environment, types of shrublands and grasslands are generally more suitable. As the existing literature mostly focuses on the effective distribution of vegetation in urban environments for noise prevention, recommendations for other urban challenges could be modelled upon that data. General planning recommendations for noise-related solutions are as follows [46,49,50,72–75]:

- To achieve an absorption of 5 dBA or more, the width of the vegetation barrier (e.g., hedges, trees) must be at least 1.5 m thick.
- The most effective factors in reducing noise are the density, height, length, and width of vegetation strips, leaf size, and branching characteristics.
- Dense native evergreen shrubs higher than the noise receptor (i.e., 2–3 m high) or plant groups consisting of trees and shrubs of different heights should be planted.

- The result will be better if the vegetation belt is located as close as possible to the noise source and as far away as possible from the protected area.
- A vegetation belt that is 5 m wide is (given the trade-off between efficiency and space consumption) ideal for reducing traffic noise in urban environments.

A key limitation of the presented conceptual planning approach is that the potentially relevant HTs that can act as NBSs for specific urban challenges and the conditions for their placement in urban areas have, to date, not yet been studied enough to provide an effective solution for the sites despite the fact that in recent years there has been a growing body of research on NBSs in green urban areas [58]. The key to realising the proposed approaches to spatial planning will be the acquisition of new, interdisciplinary knowledge on HTs, such as the suitability of a specific HT to address urban challenges, the multifunctionality of a specific HT, the possibility of implementing HTs in typical spatial (morphological) units of spatial planning, the appropriate dimensioning of HTs, the required time for HT growth, and their growth phases. Based on this additional knowledge, future research will be able to make more in-depth recommendations for spatial planning and provide a better argued evaluation of HTs for their placement in urban space, as it is obvious that their implementation competes for space with other areas and objects. However, at the same time, in addition to HT benefits, they can also bring negative effects to urban spaces (e.g., presence of mosquitoes, allergenic pollen in the air, untidy appearance, space for vandalism, etc.) [59]. Our study has demonstrated the need for closer examination of the potential of HTs for urban planning and enhancing quality of life based on their processes, functions, and environmental and spatial requirements.

We define HTs, based on the minimum necessary surface for effective utilisation, as a form of NBS that is suitable to different land uses (such as residential, commercial, community facilities, transport, industrial, and green areas) and not as a substitute for any individual land use. The proposed minimum surfaces of HTs as NBSs for each studied societal challenge (1 m^2 and 5 m^2) are based on the integration of interdisciplinary knowledge and supported by similar examples of boundary setting. For example, various definitions of a pond define it (based on size) with a lower limit of 1 m^2 [60]. Minimum sizes of other landscape elements, such as hedgerows for the implementation of agricultural policy measures, are also defined in metres (lines of woody vegetation at least 10 m long and no more than 20 m wide at the canopy) [61]. As discussed above, with more interdisciplinary knowledge on HTs, the order of magnitude for each HT may change. We have started the discussion on minimum areas, but it would also be useful to address the maximum reasonable area of a given HT for urban environments, carrying capacities for occupancy, as well as nature itself (e.g., [62]).

6. Conclusions

An approach to the inclusion of HTs as NBSs in spatial planning acts is based on: (a) current knowledge about the effectiveness of different vegetation types and water surfaces in urban environments in solving urban challenges, (b) the criteria, main characteristics, and principles of NBSs as a concept and solution in an urban environment, (c) defined parameters of HTs as NBSs and their values, and (d) the characteristics of spatial planning documents. The results of this paper clarify why HTs can be treated as NBSs in urban planning and under what conditions and, more precisely, which aspects we must take into consideration. We discovered that each urban challenge can be addressed and solved with a number of HTs from local areas serving as NBSs. Moreover, most of these HTs can simultaneously address more than one challenge, which justifies their implications. The findings of the content analysis of NBS documents provide strong support for innovative applications of NBSs based on new knowledge about HTs and their interdisciplinary connections, such as to biology from the HT perspective, to urban planning from the implementation perspective, and to other urban challenge-related disciplines. The defined HT and urban planning aspects, which are based on the criteria and principles of NBSs, helped us to link these disciplines, argue for HTs as NBSs, and explain their relationships. The use of HTs in spatial planning supports urban policy efforts to contribute to the diversity of native species by classifying HTs (hitherto considered exclusively as nature conservation units) as spatial units with added value that facilitate improved and more resilient cities and higher biodiversity within urban environments. This proposal, based on interdisciplinary ideas and assumptions, offers an opportunity for more sustainable spatial planning.

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