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Urban wilderness: Supply, demand, and access☆

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ABSTRACT

The concept of urban wilderness feels like a paradox since natural and urban environments have long been viewed as antithetical. Today, however, wilderness is high on the urban agenda as a response to different challenges: biodiversity and human experiences of nature are being lost in increasingly dense cities, while at the same time a plethora of wild areas are developing in cities that are undergoing post-industrial transformation. Yet there is confusion around the definitions and the anticipated functions of urban wilderness and how humans can be incorporated therein. A unifying framework is proposed here that envisions urban wilderness as a social-ecological system; three major components are identified and linked: (i) the supply of wilderness areas along gradients of naturalness and ecological novelty, leading to a differentiation of ancient vs. novel wilderness, and the identification of wilderness components within cultural ecosystems; (ii) the demand for wilderness in urban societies, which differs among sociocultural groups as a function of underlying values and experiences; (iii) the access to urban wilderness, which can be improved both in terms of providing opportunities for encountering urban wilderness (e.g., by conserving, rewilding wilderness areas) and enhancing the orientation of urban people towards wilderness (e.g., through information, environmental education, citizen science). Evidence from urban wilderness projects in Europe demonstrates that multi-targeted approaches to conserving and managing existing novel urban ecosystems offer manifold opportunities to combine biodiversity conservation and wilderness experience in cities.

1. Approaching urban wilderness as a social-ecological system

Wilderness is a fascinating concept that has been deeply rooted in Western cultural history since ancient and medieval times (Oelschlaeger, 1991; Kirchhoff and Trepl, 2009; Kirchhoff and Vicenzotti, 2014). With the accelerating transformation of former wildlands into developed land—a global phenomenon today (Ellis, 2015)—attempts to conserve or restore wilderness areas have grown and continue to grow in importance. While initially, in the 19th century, large natural areas were the focus of conservation efforts (Oelschlaeger, 1991), wilderness is now also a part of the urban agenda (e.g., Diemer et al., 2003; Kowarik and Körner, 2005; Jorgensen and Tylecote, 2007; Rink, 2009; Vicenzotti and Trepl, 2009; Jorgensen and Keenan, 2012; Gandy, 2013a). This is a surprising development since wilderness and urban environments have long been traditionally viewed as antithetical (Cronon, 1996; Vicenzotti and Trepl, 2009).

Wilderness has been addressed quite differently across disciplinary perspectives (e.g., Ridder, 2007; Hofmeister, 2009; Lupp et al., 2011; Threlfall and Kendal, 2017). Ecologists and conservationists often define wilderness and related terms (e.g., wildlands, wildness, wild ecosystems) as the virtual absence of human impacts (e.g., Ellis et al., 2010). Wilderness areas, according to the influential US Wilderness Act, are those that “have been affected primarily by the forces of nature, with the imprint of man’s work substantially unnoticeable” (Wilderness Act, 1964). Social or cultural scientists, in contrast, often highlight wilderness as a cultural construct that is inextricably linked to social values and beliefs (Kirchhoff and Vicenzotti, 2014), leading ultimately to the insight that wilderness is what people perceive as wilderness. Studies from environmental psychology correspondingly reveal a broad array of objects described as wild, or associated with wilderness, although these conspicuously differ in the degree of human-mediated modification of natural conditions from areas “with thick vegetation” to areas “untouched by human influence” (Bauer, 2005). Thus, the naturalness–wilderness relationship that can be postulated from an ecological perspective (see 2.3) does not necessarily translate to the social sphere.

Although scholars from cultural or social sciences may argue that wilderness, as a cultural construct, cannot be defined in ecological

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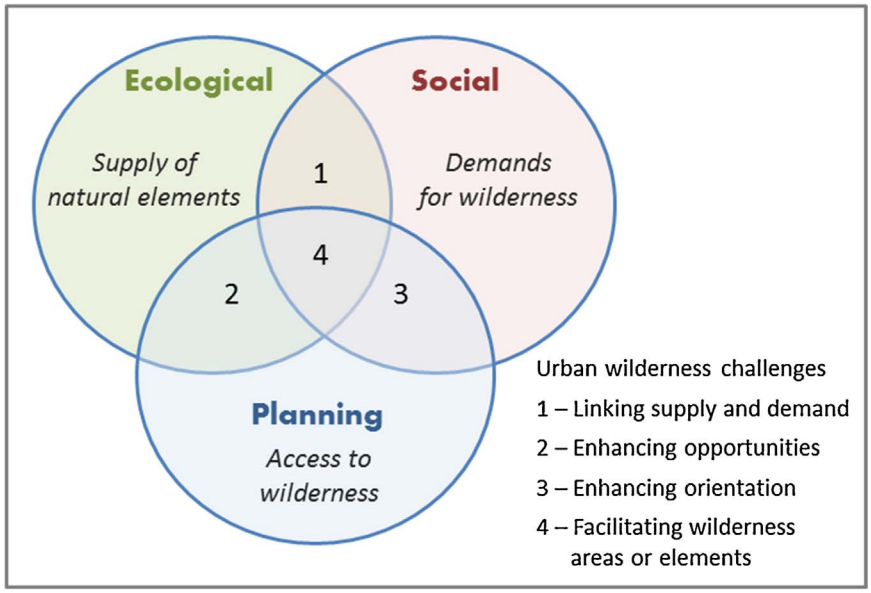

Fig. 1. Urban wilderness as a social-ecological system: three overlapping dimensions and related challenges.

terms (Kirchhoff and Trepl, 2009; Kirchhoff and Vicenzotti, 2014), conservation concepts largely do rely on the latter. Naturalness assessments, for example, are used to screen for potential wilderness areas or to define target communities for wilderness-related restoration efforts (e.g., Heneghan et al., 2013). Identifying potential wilderness components from an ecological perspective can support related planning approaches that usually refer to spatially discrete objects. Ecological approaches are also useful to link the urban wilderness agenda with biodiversity conservation—efforts that must increasingly consider societal demands (Martin et al., 2016).

The failure to incorporate the human dimension into wilderness concepts has been criticized in general (e.g., Cronon, 1996) and in particular for urban settings (Gandy, 2016). Even large wilderness areas have functioned as habitats of (indigenous) people, and human uses are clearly linked with wild areas in cities, from forests (urban foraging, recreation; Poe et al., 2013; Jankovska et al., 2014) to wastelands (Rupprecht et al., 2015; Brun et al., 2017). Considering the nature of cities as social-ecological systems (Alberti et al., 2003; Pickett et al., 2011), this paper argues for a unifying urban wilderness concept that links the social and ecological dimensions of wilderness, and ties both of these to planning approaches (Fig. 1). Such an integrated approach faces three challenges:

- To identify natural elements in cities that might meet demands for wilderness in urban societies; this is the supply side, which can be addressed through ecological approaches.
- To understand the demand side, which necessitates a social-science approach as preferences for urban wilderness clearly depend on underlying values (Ives and Kendal, 2014).
- To provide both physical and mental access to urban wilderness, which must be addressed through planning and governance approaches that build on insights from the first two issues.

The ecological, social, and planning dimensions of the proposed wilderness concept are thus intertwined (Fig. 2).

2. Ecological dimension: supply of natural elements

The ecological dimension of urban wilderness helps identify the supply of natural areas or elements in cities that may satisfy wilderness demands from urban societies. These natural components can be further targeted by planning or governance approaches that aim to enhance access to wilderness. Exploring urban wilderness from an ecological perspective raises vital questions about the type and scale of relevant natural components. Here, I argue for a broad approach that highlights multiple opportunities for urban people to encounter natural components in urban areas. These rendezvous with urban nature may then translate to urban wilderness experiences. Whether they really do—and for whom—is a question to be explored through social-science approaches.

2.1. Urban ecosystems as mosaics of transformation stages

Cities have been described as mosaics of ecosystems that are highly heterogeneous in terms of size, fragmentation, population density, and land use (Sukopp, 2002; Alberti, 2005; Ramalho and Hobbs, 2012). Important insights from a wealth of studies include the omnipresence of natural elements in cities, from single species to communities and ecosystems, and the potential of urban habitats to harbor a conspicuously high biological richness (McKinney, 2002; Kühn et al., 2004; Shwartz et al., 2014), both in ancient wilderness remnants and in novel systems (Lundholm and Richardson, 2010; Kowarik, 2011; Bonthoux et al., 2014).

Urban systems are subject to different degrees of human interference, leading to a stepwise transformation of pristine ecosystems to novel urban ecosystems (Kowarik, 2011; Ramalho and Hobbs, 2012). The “Four Natures approach“ (Kowarik, 1992) narrows down the variety of transformational stages in urban settings to four major types that can supply wilderness in urban regions (Fig. 3). Each of the four types relates to nature in general but results from different trajectories in human-nature interactions: Nature 1 represents remnants of pristine ecosystems (e.g., forests, wetlands); Nature 2 patches of agrarian or silvicultural land uses (e.g., fields, managed grasslands, cultivated forests); Nature 3 represents designed urban greenspaces (e.g., parks, gardens); and Nature 4, novel urban ecosystems (e.g., wastelands, vacant lots, heaps) that can emerge after a rupture in ecosystem development, e.g., in the wake of building activities.

The Four Natures approach predates the novel ecosystem concept of Hobbs et al. (2013), but maps to it easily: Nature 1 parallels Hobbs “historical ecosystems”, Nature 4 clearly corresponds to “novel ecosystems”, while “hybrid ecosystems” largely overlap with Natures 2 and 3. The trajectory of manifestations of Nature 1 to those of Nature 4 can thus be arranged along a gradient of ecological novelty (Fig. 3), in terms of both novel habitats and novel species assemblages since the abundance of nonnative species usually increases with ongoing transformation of urban habitats.

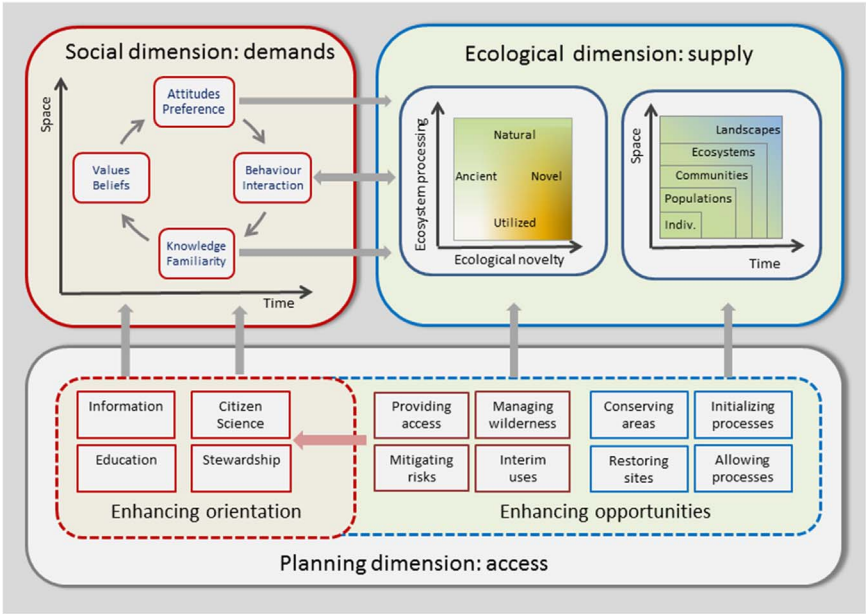

Fig. 2. Major components of the ecological and social dimensions of urban wilderness and related connections to planning approaches.

2.2. Ancient urban wilderness

The strong human component in many manifestations of urban nature evokes the question of which of the four types of nature are relevant for urban wilderness. Traditional wilderness approaches largely rely on natural remnants of pristine landscapes, that is on Nature 1, areas "where the earth and its community of life are untrammeled by man" (Wilderness Act, 1964) or on "unmodified or slightly modified land … retaining its natural character and influence" (IUCN, 1994).

Remnants of pristine landscapes do exist in many urban regions including coastal ecosystems in California cities (Schwartz et al., 2013); the "Chicago wilderness," which includes a range of natural remnants (Heneghan et al., 2013); fynbos ecosystems in Cape Town (Rebelo et al., 2011); natural grassland and forest remnants in Melbourne (Ives et al., 2013); and forests and wetlands in Berlin (Sukopp, 1990). Such manifestations of Nature 1 can be conceptualized as *ancient wilderness* since the configuration of their biotic and abiotic components can be easily related to natural historical benchmarks, despite common changes to ecosystems due to former or current urban influences.

Relating wilderness exclusively to "untouched" natural remnants has long been criticized, however, for disregarding that human populations were integral components of many such areas and that they had a role in shaping pristine landscapes, e.g., by hunting or using fire (Oelschlaeger, 1991). Using pristine environments as the sole baseline for conservation policies has been questioned (Hobbs et al., 2013; Corlett, 2016). This is particularly relevant for urban wilderness for two reasons: (i) urban land uses, climate change, and other components of global change have induced a deviation of natural ecosystem development from historic wilderness stages and (ii) novel environmental settings are increasingly emerging in the wake of severe human modifications of landscapes and need to be considered in biodiversity conservation (Kowarik, 2011; Hobbs et al., 2013). In the face of the increasing importance of novel ecosystems in cities, novel opportunities for wilderness emerge as well and can be integrated into urban wilderness policies.

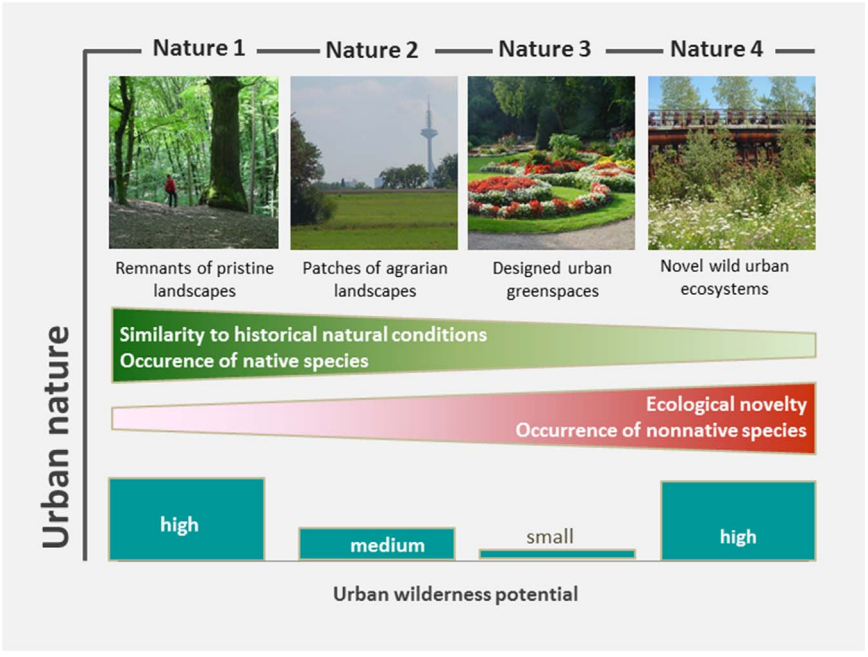

Fig. 3. The "Four Natures approach" (Kowarik, 1992; expanded) differentiates the major types of urban nature that represent transformational stages from pristine to urban landscapes; these types differ in land-use legacies, current uses, and ecological characteristics, but all contribute to wilderness supply in cities, albeit to different extents as symbolized by the sizes of bars.

2.3. Novel urban wilderness

Ecosystems characterized by a high level of naturalness can generally be related, from an ecological perspective, to wilderness. Whether the types of urban nature that are closely related to current or former human activities (i.e., Nature 2–4) matter in terms of wilderness is thus related to assessments of their naturalness. But how do we define naturalness, which is itself, as is wilderness, an ambiguous term (Kowarik, 1988; Ridder, 2007)?

A long European tradition of conceptualizing naturalness has yielded a wealth of approaches that can be assigned to one of two perspectives (as reviewed in Kowarik, 1988; see also Ridder, 2007). In the first, naturalness is perceived in terms of pristine landscapes, virtually untouched by humans, that serve as historical benchmarks (e.g., von Hornstein, 1950; Ellenberg, 1963); this definition clearly corresponds to the wilderness idea as expressed in the U.S. Wilderness Act (1964) or the related IUCN definitions (Dudley, 2008). From the second perspective, in contrast, naturalness (or hemeroby, as a measure of human impact; Jalas, 1955; Sukopp, 1972) is defined solely as a high level of self-organization in ecosystem processes from which current human interferences are absent—without any reference to a historical baseline (Kowarik, 1988). Such a state may be achieved even after severe human-mediated shifts in environmental conditions. In this formulation, manifestations of novel urban ecosystems (Nature 4) can also be understood as natural, and these may be conceptualized as *novel wilderness* in contrast to *ancient wilderness* (Fig. 4a).

Urban wilderness areas can thus be defined, from an ecological perspective, as places characterized by a high level of self-regulation in ecosystem processes, including population dynamics of native and nonnative species with open-ended community assembly, where direct human impacts are negligible. A high level of self-regulation is a shared feature of novel and ancient wilderness, but only the latter corresponds to historical benchmarks. Novel wilderness areas in urban regions can emerge in small plots of derelict land, e.g., on abandoned lots (Sitzia et al., 2016), railway areas (Westermann et al., 2011), cemeteries (Gandy, 2012; Kowarik et al., 2016), and a range of informal green elements within the urban matrix (Rupprecht and Byrne, 2014), or they can cover hectares in post-industrial landscapes (Kowarik and Körner, 2005; Haase, 2008; Burkholder, 2012). Examples from Berlin (Table 1) illustrate that novel ecosystems of different land-use legacies, sizes and positions within the urban fabric can be integrated formally into the urban green infrastructure.

2.4. Wilderness opportunities in urban ecosystems

Remnants of Nature 1 in urban settings usually include traces of current human-nature interactions. These may result from direct impacts such as recreational activities (Hamberg et al., 2008; Jankovska et al., 2014) or, indirectly, from nutrient influxes (Alberti, 2005) or species invasions (Gavier-Pizarro et al., 2010; Kowarik et al., 2013). Depending on the proportion of self-regulation and human interference, remnants of ancient wilderness can thus vary in their position along the naturalness gradient. The same holds for novel wilderness areas, which are often subject to an array of informal land uses (Rupprecht and Byrne, 2014; Brun et al., 2017). Related impacts as well as deliberate interventions (see 4.1) may reduce the level of self-regulation in ecosystem processes and thus the degree of naturalness in such areas.

Accordingly, manifestations of the other main types of urban nature (Nature 2, Nature 3) can be assigned to positions on the naturalness gradient as indicated by the colored dots in Fig. 4b. Moreover, ecological novelty can be understood as a gradient as well since the existence of an insuperable threshold between novel ecosystems (Nature 4) and hybrid ecosystems (Nature 2, 3) as postulated by Hobbs et al. (2013) can be questioned (Corlett, 2014). In consequence, urban ecosystems can be located in a two-dimensional space defined by gradients of naturalness and novelty as depicted in Fig. 4b. This helps visualize urban wilderness opportunities. The colored dots in Fig. 4b symbolize waypoints along a typical trajectory from Nature 1 to Nature 4 along the naturalness and novelty gradients. New wilderness areas can arise anywhere along the trajectory when they approach a maximum level of naturalness via succession as indicated by the arrows labelled “w” in Fig. 4b. An example of such processes is the emergence of wild forests on 19th century cemeteries (Kowarik et al., 2016), or the transformation of managed to natural forests at the urban fringe of Zurich (Commarmot et al., 2005).

Wilderness components within cultural urban ecosystems, such as wild animals or tree snags in city parks, also add to the wilderness supply in urban settings. Such components can be fostered within a range of land-use types, e.g., edible wild plants in parks (Palliwoda et al., 2017), without converting these into wilderness areas. This wilderness potential within culturally shaped ecosystems is labelled as Δw (delta wild) in Fig. 4b and symbolizes the manifold opportunities to upgrade natural elements of ecosystem components or to allow ecological processes by means of wilderness-friendly management of urban green spaces without calling into question the cultural character of the area (see 4.1.2).

2.5. Wilderness components across temporal and spatial scales

Traditional wilderness approaches usually target large areas (Dudley, 2008). Yet, citing the insight by Aldo Leopold that “no tract of land is too small for the wilderness idea,” Diemer et al. (2003) drew attention to the wilderness potential of small- and medium-sized areas including for urban regions. Although they do propose thresholds for wilderness and rewilding areas, from an ecological perspective, wild natural elements exist across a broad spatial scale, stretching from individual plants and animals up to the landscape scale (Fig. 2). As all of these can be understood as wilderness components, establishing spatial thresholds would be an arbitrary decision. Cronon (1996) argued, for example, that a tree in a garden is as “wild” as a tree in an ancient forest, although the two trees may function as carriers of different meanings: the latter “can teach us to recognize the wildness we did not see in the tree we planted in our own backyard.” Animals, in particular large mammals, offer wilderness experience in urban settings (Gehrt et al., 2010), yet urban encounters with foxes (Gloor et al., 2001), wild boars (Stillfried et al., 2017), or coyotes (Mitchell et al., 2015) are not necessarily confined to wilderness areas.

Beyond the spatial scale, time also matters for the supply of urban wilderness components. Take again a single tree as an example: a young individual is less likely to be perceived as a wilderness component than a mature tree or a fallen tree, covered with mosses or fungi (Gundersen et al., 2017). The same can be anticipated for successional stages at the community or ecosystem scale, which are often differently valued by urban people (Brun et al., 2017; Mathey et al., 2017).

3. Social dimension: demands for urban wilderness

Wilderness concepts have always been linked to human values, and these differ conspicuously across time and among societies, social-cultural groups, and regions (Oelschlaeger, 1991; Cronon, 1996; Kirchhoff and Vicenzotti, 2014; Rupprecht et al., 2015; Fig. 2). Thus, wilderness is perceived in quite different ways, e.g., as a sphere of amorality, a sacred site or as a place of fear, of nature's self-reassertion, of escape from rules and restrictions, or of relief from stressful daily life.

The general idea of urban wilderness seems to have gained acceptance in the Western world. In the recent German Nature Awareness Study (BMUB and BfN, 2016), a majority of respondents agreed “absolutely” (25%) or “slightly” (44%) that places should exist in cities where nature can develop on its own. A study from Brisbane and Sapporo suggests that informal urban green spaces are used more often than anticipated (Rupprecht et al., 2015). Such results suggest openness towards urban wilderness but cannot be generalized since urban

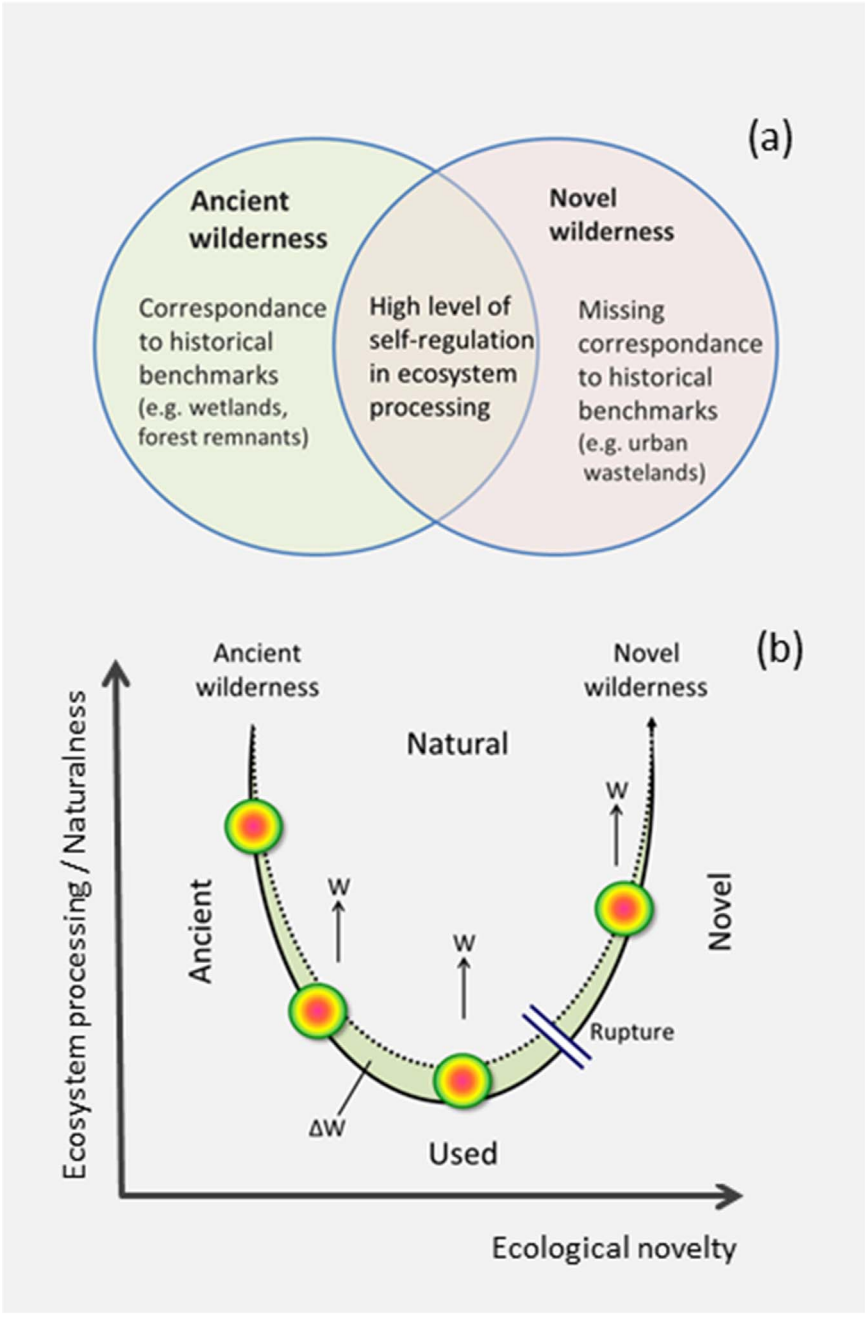

Fig. 4. (a) Wilderness can be defined, from an ecological perspective, by a high level of naturalness (i.e., self-regulated ecosystem processes) and can be differentiated into ancient or novel wilderness; (b) Urban ecosystems can be arranged along gradients of naturalness (or self-regulated ecosystem processes) and ecological novelty; the colored dots symbolize waypoints along a typical trajectory from Nature 1 to Nature 4 (from left to right, see text for explanation) along these gradients; Δw (delta wild) illustrates opportunities for fostering natural elements within each manifestation of urban nature. Arrows indicate the rewilding potential inherent in urban nature.

wilderness studies from the developing world are scarce (but see Desai and Samant, 2016a,b) as are comparative international studies (Rupprecht et al., 2015, 2016).

However, previous studies on specific urban wilderness configurations revealed ambiguous attitudes towards urban wilderness (Bauer, 2005; Jorgensen and Tylecote, 2007; Rink, 2009; Zheng et al., 2011; Weber et al., 2014). For example, Weber et al. (2014) differentiated "wilderness enthusiasts" vs. "urban devotees" who preferred either wild vegetation or intensively managed vegetation in an urban streetscape. Most of those who preferred a manicured greenspace nevertheless also attributed value, in terms of ecosystem services, to the wild vegetation. Moreover, people often attribute different characteristics to "wild" and "natural" areas, with more positive valuations of the latter, which tend to be more associated with order (Nassauer, 1995; Brun et al., 2017).

While the importance of sociocultural background in valuing wilderness is broadly acknowledged (Bauer 2005; Buijs et al., 2009), research on the views of people of different backgrounds on urban nature is limited (Botzat et al., 2016). The few studies on this issue found higher preferences for urban wilderness in experts vs. laypersons (Hofmann et al., 2012), in younger vs. older people (Mathey et al., 2017), or with regard to education background (Zheng et al., 2011). Rupprecht et al. (2015) discussed cultural explanations of similar activities in children, but not in teenagers, in the use of vacant lots in Brisbane vs. Sapporo. This study also suggested that growing safety concerns by parents may limit current uses of urban wilderness areas by children more than in former times (Rupprecht et al., 2015)—a nice example of social values changing over time.

Differing valuations can arise based on structural features of urban wilderness components. For urban wastelands, there is evidence that intermediate succession stages are preferred over both pioneer and late successional stages (Brun et al., 2017; Mathey et al., 2017). Such valuations correspond to often-found preferences for semi-open landscapes (e.g., Bjerke et al., 2006; Gundersen et al., 2017) and have been explained by an archetypal desire of humans to see without being seen

Table 1
Integration of novel urban wilderness into Berlin's urban green infrastructure. The listed areas are protected as a public greenspace (park) or have a formal conservation status according to the German Nature Conservation Act as NSG (nature conservation area), LSG (landscape conservation area), GLB (conserved landscape component), or as a European conservation area − FFH (Flora, Fauna, Habitat area); most areas support multiple targets and differ with regard to intervention into wilderness dynamics.

Area (size, year of establishment)	Previous use	Protection status	Location within city	Main targets	Main interventions	Comments
Park Hallesche Straße/ Möckernstraße (0.7 ha; 1987)	Vacant lot	GLB	Core	Wild urban ecosystems, nature experience	Path system	Wild forest patch, non-native tree dominance
Park am Gleisdreieck (26 ha; 2013)	Freight railyard	Park	Core	Recreation, nature experience, large wild forest patch, virtually fenced	Designed area, naturalistic plantings, inclusion of wild vegetation	Wild forest patch, native tree dominance; local NGOs supported wilderness conservation
Park am Nordbahnhof (5.5 ha; 2009)	Railway station	Park	Core	Recreation, nature experience	Path system, design interventions, working with ruderal vegetation	Mosaic of managed dry grassland and wild forests
Tempelhofer Feld (300 ha; 2010)	Airfield	Park	Core	Recreation, grassland, farmland birds	Grassland management in the core area, temporary uses in surrounding areas	Successful referendum (2014) for conserving existing nature prevented traditional park design
Natur-Park Südgelände (16.7 ha; 1999)	Freight railyard	NSG, LSG	Inner fringe	Development of wild forests, grassland, endangered species, nature experience	Path system, pieces of art, grassland maintenance by grazing	Mosaic of native/non-native forest patches and grassland; local NGO supported wilderness conservation
Flugfeld Johannisthal (26 ha; 2002)	Airfield	NSG, LSG	Inner fringe	Grassland mosaic, endangered species, recreation in LSG	Grassland maintenance, path system and designed areas in LSG	Only visual access to core area (NSG), recreation activities around
Spandauer Zitadelle (13.1 ha; 1959)	Fortress	LSG, FFH	Inner fringe	Heritage site with cavities (bats), forest development	Maintenance of historical structures	Limited access
Grünauer Kreuz (34.2 ha; 2004)	Railway area	NSG	Outer fringe	Grasslands, forest succession, endangered species	Grassland maintenance	No public access
Fort Hahneberg (29.2 ha; 2009)	Fortress	NSG, FFH	Outer fringe	Heritage site with cavities (bats), wild forests, grassland, endangered species	Maintenance of historical structures, grassland maintenance	Limited access (guides tours)
Falkenberger Rieselfelder (60 ha; 1995)	Sewage farm	NSG	Outer fringe	Semi-open forests, hedges, grassland, wetland, endangered species, recreation	Grazing, path and information systems, some agricultural uses	Public access on paths
Rieselfelder Karolinenhöhe (220.4 ha; 1987)	Sewage farm	LSG	Outer fringe	Recreation hedges, grassland,	Path system, agricultural uses	Public access

(prospect-refuge theory, Appleton, 1975).

The cognitive hierarchy model of human behavior illustrates pathways between such values and other cognitive elements (beliefs, attitudes, preferences, behavioral intentions; Fig. 2, top left) that ultimately relate to behavior, such as interactions with urban wilderness components or participation in conservation initiatives (see Ives and Kendal, 2014 for details). Insights on the changeability of cognitive elements—increasing from values to behavioral intentions (Fulton et al., 1996)—are important as they help identify starting points for providing access to urban wilderness.

How people behave, e.g., by visiting, observing or interacting with nature in urban wilderness areas (or other environments), largely depends on underlying values, beliefs, attitudes, and preferences. Previous work on the motivation of people to visit informal urban greenspaces demonstrates a wealth of different motivations (Rupprecht et al., 2015, 2016). Obviously, for some, wastelands and other informal green areas meet demands that are not satisfied by traditional urban green spaces, while others dislike such areas. Encounters with wild natural components as well as escape from rules and regulations are important attractions of such sites, with differences among regions, sociocultural groups, and gender (Gandy, 2012; Rupprecht et al., 2015). "Otherness," i.e., the contrast to traditional green spaces in terms of both ecological (e.g., wild vs. tamed) and social patterns (e.g., controlled vs. self-determined), has been highlighted as an important attraction of such spaces (Ward Thompson, 2012; Gandy, 2013a; Rupprecht et al., 2015).

Moreover, long-term experience, familiarity, and knowledge about natural settings shape values and related preferences and behavior in urban greenspaces (Gustafson, 2001; Meinhold and Malkus, 2005; Kappas, 2006). As a consequence, providing information about social and ecological functions of urban wilderness can modulate people's valuation patterns.

In conclusion, understanding how natural components in cities are valued in terms of wilderness, and which mechanisms shape underlying patterns in valuation and behavior, helps link supply and demand factors—an important, although often underestimated, task in urban greenspace development (Hegetschweiler et al., 2017).

4. Planning dimension: paving access to urban wilderness

Urban residents, particularly young people, are choosing to spend less time experiencing nature (Ward Thompson, 2012; Soga and Gaston, 2016). At the same time, opportunities for people to experience wilderness are decreasing in cities as they become increasingly built up (Lin and Fuller, 2013). Considering that these trends decrease benefits to people's health and well-being arising from contacts with nature (Shanahan et al., 2015), two challenges emerge for urban planning (Soga and Gaston, 2016): first, to provide opportunities to encounter urban nature, and second, to support people's orientation towards

urban nature. In this vein, approaches are needed to facilitate access to wilderness in urban environments physically, e.g., by conserving or establishing wilderness areas or elements, and also mentally, by exploring opportunities to enhance the orientation of urban people towards wilderness.

4.1. Enhancing opportunities

There are three main, intertwined pathways to ensure opportunities for wilderness contacts in urban settings: to conserve existing wilderness areas, to foster the development of wilderness in culturally shaped areas, and to provide access to existing and emerging wilderness areas. The examples in Table 1 illustrate the potential of multifunctional urban wilderness areas, demonstrating a range of combined targets that are related, for example, to natural ecosystem processes, biodiversity conservation, cultural heritage, recreation, nature experience, and environmental education.

4.1.1. Conservation

Urban growth and densification pose risks to extant wilderness areas, both at the urban fringe and within the urban fabric (McDonald et al., 2013; Soga et al., 2014). This implies significant losses of areas as well as threats to species in remaining areas, e.g., from hunting (Parry et al., 2014; Desai and Samant, 2016a). Protecting old-growth forests or natural wetlands as manifestations of ancient wilderness in urban regions should thus be high on the urban wilderness agenda and has been achieved by establishing conservation areas within many cities or their fringes.

Adding Nature 4 to the urban wilderness agenda is promising because areas with novel urban nature are often located close to urban people. Nature 4 areas also allow access to the wilderness experience in regions where ancient wilderness has been lost due to urbanization or intensive agriculture. In Brisbane and Sapporo, for example, the wild character was an important reason that children visited informal greenspaces (31–54% of respondents), but the vicinity to home was even more important (77–81%, Rupprecht et al., 2016).

The supply of novel wilderness areas varies conspicuously as a function of the socioeconomic development of urban regions. It is usually low in quickly growing cities, represented by small patches or linear areas along transportation corridors (Rupprecht et al., 2014), but in regions that are “shrinking” due to economic decline, the supply can be high, often covering large areas (Kowarik and Körner, 2005; Haase, 2008; Burkholder, 2012; Nassauer and Raskin, 2014).

It was most likely in shrinking regions of Germany that novel wilderness areas were first formally included into urban green systems; first in Berlin (Lachmund, 2013) and the Ruhr, and later in the post-Communist eastern parts of Germany (Kowarik and Körner, 2005; Haase, 2008; Rink and Herbst, 2011). In Berlin, some of these areas have been protected as nature conservation areas; others are formally integrated into parks (Table 1). In the Ruhr region, large post-industrial areas are now part of (inter-)urban green systems known as the “Landschaftspark Duisburg-Nord” (180 ha) and 17 other areas now described as “industrial forests” (ca. 244 ha; Dettmar, 2005).

Formalizing interim uses of urban wastelands is an additional approach to provide access to urban wilderness (Rall and Haase, 2011) that also offer opportunities for temporal biodiversity conservation (Kattwinkel et al., 2011). Highlighting informal uses, as was done for the largely abandoned railway circle around Paris (“petite ceinture”, Scapino, 2016), can support the integration of parts of these wild areas even into highly dense cities.

4.1.2. (Re)wilding

For abandoned rural landscapes, “rewilding” strategies have been proposed to allow the development of new wilderness areas (Navarro and Pereira, 2012; Corlett, 2016). A wealth of approaches from restoration ecology could support this process, including reintroducing species, restoring biotic or abiotic environmental conditions, or simply allowing natural processes to occur with little or no human interference (“passive rewilding,” Corlett, 2016). Rewilding approaches have also long been considered for urban areas, mostly with a focus on cultural ecosystem services (e.g., Andritzky and Spitzer, 1981; Loidl-Reisch, 1986; Trommer, 1997; Diemer et al., 2003; Körner, 2005). The underlying German concept of *Verwilderung*, which can imply an undefined or open-ended development towards wilderness (e.g., Diemer et al., 2003), can have negative connotations, however, in particular when applied to culturally shaped greenspaces. *Verwilderung* is the wilderness potential indicated by the arrows labelled “W” in Fig. 4b. In contrast, “delta wild” in Fig. 4b indicates the potential for accommodating wilderness components, or processes, within an existing cultural form without threatening its existence.

Classical restoration approaches that make reference to historical conservation baselines are often applied to (near) natural remnants, for example within the Chicago wilderness framework (Heneghan et al., 2013) or the Knoxville Urban Wilderness. Related approaches also exist for novel urban ecosystems, e.g., for the greening of vacant lots as reviewed by Anderson and Minor (2017) or forest plantings on urban wastelands (Rink and Arndt, 2016). A broad range of (mostly) European approaches rely on the manifold opportunities that existing novel habitats and species assemblages offer for wilderness development and experience. Many of the reported projects (Kowarik and Körner, 2005; Jorgensen and Keenan, 2012; Prominski et al., 2014; Mathey et al., 2015) share three common features:

- Working with existing urban nature and remains of technical structures.
- Combining objectives related to biodiversity conservation, cultural ecosystem services (e.g., recreation, nature experience, environmental education, cultural heritage) and other ecosystem services.
- Combining approaches to intervene in natural ecosystem processes in some parts of an area through design, management or, indirectly by regulating uses, while not intervening in other parts of the same site.

Evidence from established urban projects thus illustrates many opportunities for integrating wilderness into urban greenspace systems, and most projects successfully combine social goals with biodiversity targets (Fig. 5). Projects clearly differ in the proportion of land where natural ecosystem processes are allowed to regain dominance and the area where wilderness development is arrested, regularly or occasionally, e.g., to maintain open habitats on potential forest sites. On former airfields, for example, large grassland areas are maintained by grazing or mowing as these areas significantly contribute to urban grassland conservation (Fischer et al., 2013a) and benefit endangered farmland birds. Temporo-spatial variance in grassland management leads to heterogeneous patterns (Fig. 5g), and the inclusion of unmanaged areas increases the structural diversity. Introducing mega-herbivores to former sewage farms (Table 1) has led to semi-open woodlands, while undisturbed woodland succession is allowed in other areas (Fig. 5). In the post-industrial wastelands of the Ruhr, repeated interventions are undertaken to prevent forest development in some parts in order to keep open sites with bare soils, early successional stages, and shallow temporal wetlands (Fig. 5h). Such measures support species of conservation concern that are largely confined to open areas, such as pioneer plants and some amphibians (Keil et al., 2013), grassland species (Fischer et al., 2013a), and farmland birds (Meffert and Dziock, 2012).

In addition to large urban wilderness projects, smaller wilderness components can be enhanced in urban greenspaces as indicated by Δw in Fig. 4b (examples in Fig. 5i–j). Spontaneous vegetation as a ubiquitous wilderness component can be integrated into planting designs for parks (Kingsbury, 2004; Kühn, 2006; Gandy, 2013b) and gardens (Goddard et al., 2010), or simply be allowed to emerge in streetscapes

Fig. 5. Different approaches to provide access to urban wilderness. (a) Fort Hahneberg (Berlin, Germany): visual access to novel forests on walls of an ancient fortress; "Natur-Park Südgelände" (Berlin): (b) access to wild forests with "untidy" structures by paths, (c) maintaining grassland by grazing creates visual accessibility; (d) "Park am Gleisdreick" (Berlin): information on wild forests and virtual fencing; "Alter Flughafen Bonames" (Frankfurt, Germany): (e) information system and design interventions to initialize forest succession and, (f), to create wetlands; (g) former airfield Tempelhof (Berlin): maintaining grassland by mowing, with spatial differentiation of access; (h) former coal mine Rhein-Elbe (Gelsenkirchen, Germany): forest succession and interventions to maintain open areas and to create wetlands; Encountering wilderness elements: (i) wild-grown tree of heaven (*Ailanthus altissima*) in a community garden (Madrid, Spain), (j) feeding animals, St. James's Park (London, United Kingdom), (k) decaying wood in Hain park (Bamberg, Germany), (l) vegetation dynamics in Parc André Citroën (Paris, France).

(Pellegrini and Baudry, 2014; Säumel et al., 2016) and a range of other urban habitats (Del Tredici, 2010). Green roofs can harbor wild-looking meadows (Lundholm, 2016)—and watching such habitats has been linked to creative and meditative thinking (Loder, 2014). Preserving mature trees and associated decay stages (Fig. 5k) is a further important pathway to wilderness experience in cities, in particular in forest remnants or large parks (Hauru et al., 2014; Gundersen et al., 2017). All of these approaches can be summarized as wilderness-friendly management of urban green spaces.

4.1.3. Invasions by nonnative species

There is a conspicuous diversity of positions about the risks and opportunities of nonnative species in cities. Highly controversial positions in the long-standing alien-native debate (e.g., Davis et al., 2011 vs. Simberloff, 2011) can be reconciled by finding different answers for ancient and novel wilderness areas. There are good arguments from both ecological and social perspectives for preventing invasions into natural remnants since they usually harbor endangered species or ecosystem types and allow urban people to experience archetypes of historical ecosystems. Such arguments justify efforts to prevent or manage invasions in ancient wilderness areas or in peri-urban settings that can be developed towards historical environmental conditions (e.g., Heneghan et al., 2013).

In contrast, nonnative species are often constitutive elements of many novel urban ecosystems (Kowarik, 2011, Fig. 3). The "otherness" of novel environmental features in these areas corresponds to the otherness of species assemblages and neither automatically conflicts with the wilderness character of such areas. In contrast, wilderness dynamics— including novel species assemblages—is also within the scope of some urban wilderness areas as the "Natur-Park Südgelände" (Kowarik and Langer, 2005) and some other areas in Berlin (Table 1). In general, there is limited evidence for threats to endangered native species by nonnative species in novel urban ecosystems. Instead it is often natural succession towards forests that conflicts with species of conservation concern as these are often confined to open habitats (see above). In this regard, it is not the origin of the predominant tree species but the shift from open to tree-dominated stands that is key for endangered native species.

The often high abundance and diversity of nonnative tree assemblages on vacant lots and other types of wastelands (Kowarik et al., 2013; Riley et al., 2017) can underpin ecosystem services, sometimes more than native tree species (Riley et al., 2017). Comparisons between native- and nonnative-dominated wild pioneer tree stands on urban grounds in Berlin demonstrated differences in species assemblages of plants and animals, but no clear advantage of the "native" or "nonnative" forest type for species of conservation concern (Trentanovi et al., 2013; Buchholz et al., 2015). Analyses of tree populations show that native tree species can recover under the canopy of nonnative species (Kowarik et al., 2013). This suggests that "passive rewilding" of novel urban ecosystems may also include opportunities for native tree species after phases of exotic dominance. Novel ecosystem dynamics with open-ended community assembly as reference to future forest development at severely changed urban sites may be an important function of novel urban wilderness.

4.1.4. Access to wilderness

Urban wilderness areas are usually used by a range of urban people, often including marginalized groups that benefit from the "otherness" of these informal greenspaces in terms of missing regulations and opportunities for interacting with natural elements (Rupprecht et al., 2015; Brun et al., 2017). Formalizing access by establishing official entrances, paths, and other green infrastructure elements (Fig. 5) usually increases the attractiveness of wilderness areas for a broad public (e.g., Unt and Bell, 2014) but risks displacing former users. Yet in the face of a decreasing motivation to encounter nature (Soga and Gaston, 2016), providing access to wilderness, both physically (e.g., in terms of infrastructure) and mentally (e.g., as information), is important: for humans, as contact with nature benefits human health and

well-being (Shanahan et al., 2015), and for biodiversity, as improving access to nature may support the nature orientation of people, with positive feedbacks to conservation (Dunn et al., 2006).

However, aesthetic and ecological values are not necessarily positively related (Gobster et al., 2007). These two classes of values can be reconciled by intervening into the species composition or the vegetation structure. Adding ornamentals (Köppler et al., 2014) or attractive native species to wasteland vegetation (Fischer et al., 2013b) may increase acceptance, assuming that the former approach relies on non-invasive species. Keeping parts of wilderness areas open by grazing or mowing (Fig. 5c,g,h) supports two aims: to enhance species of conservation concern, which are often much more likely to be found in open habitats than in young successional forests, and to meet people's preferences. Perceived accessibility is highly important for explaining people's preferences for forest structures (Edwards et al., 2012). Correspondingly, a wealth of studies demonstrate preferences for semi-open urban wastelands (e.g., Hofmann et al., 2012; Brun et al., 2017), with positively connoted human interventions that function as cues to care (Nassauer, 1995). In contrast, people usually dislike young and dense forest stands with "untidy structures like windfall, fresh woody debris" (Gundersen et al., 2017). Yet staging access to highly dynamic wild successional forests (Fig. 5b,f) has been successful in a range of projects. Generally, small design interventions can be very effective in reducing misuses by visitors (e.g., littering) and increasing the attractiveness or wilderness areas (Unt and Bell, 2014).

4.1.5. Risk mitigation

Providing access to urban wilderness also implies the need to mitigate risks resulting from natural processes and human misbehavior. Natural risks include flooding dynamics (Kangler et al., 2014), fire (Gill and Stephens, 2009), encounters with wild animals (Yeo and Neo, 2010; Desai and Samant, 2016b), disease transmission (Deplazes et al., 2004; Bradley and Altizer, 2007), and hidden risks in relation with technical structures (Kowarik and Langer, 2005). Further risks result from soil pollution, which is largely relevant for post-industrial sites (Gallagher et al., 2011; Yang et al., 2014). Experience from the vast post-industrial landscapes of the Ruhr demonstrates that management of pollution risks can be feasible without area-wide decontamination, with wild forest development as a measure to reduce contact with soils (Dettmar and Ganser, 1999; Dettmar, 2005). Correspondingly, Gallagher et al. (2011) highlight the role of wild urban ecosystems in contaminant stabilization.

Wilderness can also be associated with fear when humans face the forces of nature, feel lost in wild environments (van den Berg and Konijnendijk, 2012), or anticipate being confronted with human misbehavior. Safety issues are important—as in other types of urban greenspaces (Sreetheran and Konijnendijk van den Bosch, 2014). Littering is a specific challenge in informal greenspaces, although there may be a gap between perceived and experienced litter (Rupprecht et al., 2015). Nevertheless, collecting litter and preventing littering by a range of measures (e.g., offering bins, reducing the accessibility to cars, employing rangers or park managers) leads to an increased acceptance of urban wilderness areas (Rink and Herbst, 2011; Rall and Haase, 2011; Unt and Bell, 2013).

In a study from an Indian city, half of respondents reported accidental natural risks (snakes, rodents, insects) due to the proximity of their houses to adjacent wilderness areas (Desai and Samant, 2016b). In contrast, less than 20% of respondents in Sapporo and Brisbane have felt threatened by injury when visiting informal greenspaces as children or teenagers (Rupprecht et al., 2016). These studies illustrate the context dependence of risks and, in consequence, the need for local analyses and approaches to reduce barriers to visiting urban wilderness areas.

4.2. Enhancing orientation

Some of the previously addressed approaches to facilitate wilderness opportunities (i.e., management, access, risk mitigation) help with the perception of wilderness areas as attractive places for experiencing nature and a range of other activities. Such measures thus contribute to enhanced orientation of urban residents towards wilderness.

Since knowledge about wilderness is relevant in shaping people's attitudes and behavior in wilderness areas (see above), providing information about the historical, social, and ecological functions of wilderness areas is important (Rupprecht et al., 2015). Take the example of dead or decaying wood, a typical wilderness feature, which can evoke a sense of mystery, inspire feelings of an unpredictable environment, and offer relief from stressful daily life (see Gundersen et al., 2017). In a forest study, people tended to dislike forest stands with structures like windfall or dead wood; providing information about the ecological function of such components, however, led to more positive valuations (Gundersen et al., 2017).

A historical analysis of policies for greening Berlin (Lachmund, 2013) highlights the importance of two coinciding factors: (i) the early availability of ecological knowledge about urban wastelands (synthesized in Sukopp, 1990) and (ii) the engagement of NGOs, local groups, and scientists in protecting informal wilderness areas. This engagement strongly supported plans of local authorities to conserve wilderness areas, either as legally protected nature conservation areas or as parts of a novel type of urban park (Table 1).

Urban wilderness areas offer manifold opportunities for environmental education (Knapp et al., 2016). In the industrial forest of the Ruhr, which includes 17 forest patches within the urban fabric of a densely populated metropolitan region, education efforts have been successfully linked with safety issues: forest rangers offer tours for groups from schools and kindergartens, provide individual information, and keep these wilderness areas under surveillance (Knapp et al., 2016).

Finally, communication with and involvement of stakeholders and local communities are vital for wilderness-related planning procedures and their modification to meet local demands (Rall and Haase, 2011). Involvement of voluntary stakeholders and citizen scientists in biodiversity mappings, management, or restoration efforts (Heneghan et al., 2013) is highly promising to strengthen ties of urban people to wilderness. People can also be integrated in deciding whether and how wilderness areas or components should be developed. Participation of people from adjacent neighborhoods in planning the new "Park am Gleisdreieck" on a former railway area in Berlin revealed strong demands for integrating extant ruderal vegetation and wild pioneer forests into the new park, and these demands, after controversial discussions, allowed for modifications of the plan (SenStadtUm, 2013; Kowarik, 2015). Participation approaches can also increase public acceptance of restrictions in wilderness areas, as with hunting or walking in the Sihlwald as an emerging peri-urban wilderness area in Zurich (Seeland et al., 2002).

5. Conclusions

Wilderness in urban regions offers manifold chances to reconnect urban people with nature and to support biodiversity conservation in cities. Screening for wilderness areas along gradients of naturalness and ecological novelty amplifies opportunities for integrating wilderness into the urban green infrastructure. This involves (near) natural remnants that serve as "ancient wilderness" as well as "novel wilderness" emerging at severely modified urban-industrial sites within cities or at the urban fringe.

Yet, urban wilderness approaches should reflect not only wilderness potential from an ecological perspective but should also consider the existing diversity in attitudes towards wild urban nature. There is evidence of increasing demands for or, at least, increasing openness towards urban wilderness. A range of studies, however, also demonstrate that the desire for wilderness is not shared by all. Urban dwellers may perceive different components as wild and may view those components negatively or positively. Approaches towards more wilderness in cities are thus promising as one component of the larger green strategy.

A better understanding of the various connections within and between the social and ecological dimensions of urban wilderness and their ties to planning will enhance the opportunities for urban wilderness (Fig. 2). Many disciplines offer starting points for inter- and transdisciplinary research into urban wilderness as a social-ecological

system—cultural and social sciences, environmental psychology, ecology, planning. Linking discourses and methodological approaches from these will help with the following:

- Linking demands for wilderness in urban societies with the actual supply of wilderness areas, or wilderness components such as wild animals.
- Reconciling conflicting aims that may exist, for example, with regard to environmental preferences, recreation activities and biodiversity conservation.
- Identifying starting points for urban planning and governance to provide access to wilderness both by enhancing opportunities for urban wilderness and by exploring ways to increase the orientation of urban people towards wilderness.

Studies of the preferences of urban people have often led to the insight that design or management interventions into wilderness dynamics would increase the attractiveness of wilderness areas. This is not necessarily a contradiction to urban biodiversity conservation. Evidence from novel wilderness areas that have been integrated into urban green systems of European cities since the 1980s demonstrates that such interventions can enhance access for humans and support populations of animals or plants of conservation concerns that are confined to (semi) open habitats. Conserving wilderness by allowing interventions sounds like a paradox but can be fruitful for a range of aims. There is also significant potential for enhancing wilderness components within culturally dominated greenspaces (e.g., parks) through wilderness-friendly management without questioning the cultural dominance of such areas.

A major conclusion is thus: the urban wilderness agenda covers a broad range of assets to be detected, enhanced, and conserved—and a wealth of approaches for dealing with ancient and novel wilderness areas and components. The question thus is not whether or not to intervene or to remove or to maintain exotic species, but to search for multiple responses that acknowledge diversity in people's demands and existing urban nature.

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