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# **Wilding cities for biodiversity and people: a transdisciplinary framework**

Sébastien Bonthoux<sup>1,2,\*</sup> and Simon Chollet<sup>3</sup>

<sup>1</sup>*Ecole de la Nature et du Paysage – INSA CVL, CNRS UMR 7324 CITERES,*

*3 rue de la Chocolaterie, CS 23410 41034 Blois cedex, France*

<sup>2</sup>*LTSER, Zone Atelier Loire, UMR 7324 - CITERES, BP 60449, 37204 TOURS cedex 03, France*

<sup>3</sup>*Université de Rennes, CNRS UMR 6553 ECOBIO [Ecosystèmes, biodiversité, évolution],*

*Campus de Beaulieu - Bat 14A, 263 Av Gal Leclerc, 35700 Rennes, France*

\* Author for correspondence (E-mail: [sebastien.bonthoux@insa-cvl.fr](mailto:sebastien.bonthoux@insa-cvl.fr); Tel.: +33 6 70 36 45 80).

## ABSTRACT

Accelerating urbanisation and associated lifestyle changes result in loss of biodiversity and diminished wellbeing of people through fewer direct interactions and experiences with nature.

In this review, we propose the notion of urban wilding (the promotion of autonomous ecological processes that are independent of historical land-use conditions, with minimal direct human maintenance and planting interventions) and investigate its propensity to improve biodiversity and people–nature connections in cities. Through a large interdisciplinary synthesis, we explore the ecological mechanisms through which urban wilding can promote biodiversity in cities, investigate the attitudes and relations of city dwellers towards urban wild spaces, and discuss the integration of urban wilding into the

fabric of cities and its governance. We show that favouring assembly spontaneity by reducing planting interventions, and functional spontaneity by limiting management practices, can promote plant diversity and provide ecological resources for numerous organisms at habitat and city scales. These processes could reverse biotic homogenisation, but further studies are needed to understand the effects of wilding on invasive species and their consequences. From a socio-ecological perspective, the attitudes of city dwellers towards spontaneous vegetation are modulated by successional stages, with grassland and woodland stages preferred, but dense shrubby vegetation stages disliked. Wild spaces can diversify physical interactions with nature, and enrich multi-sensory, affective and cognitive experiences of nature in cities. However, some aspects of wild spaces can cause anxiety, feeling unsafe, and the perception of abandonment. These negative attitudes could be mitigated by subtle design and maintenance interventions. While nature has long been thought of as ornamental and instrumental in cities, urban wilding could help to develop relational and intrinsic values of nature in the fabric of cities. Wildness and its singular aesthetics should be combined with cultural norms, resident uses and urban functions to plan and design urban spatial configurations promoting human–non-human cohabitation. For urban wilding to be socially just and adapted to the needs of residents, its implementation should be backed by inclusive governance opening up discussion forums to residents and urban workers. Scientists can support these changes by collaborating with urban actors to design and experiment with new wild spaces promoting biodiversity and wellbeing of people in cities.

*Key words:* rewilding, transdisciplinarity, urban landscape, conservation science, socio-ecological system, people–nature connection, urban biodiversity, nature experience, urban planning, urban design.

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## **I. INTRODUCTION**

In 1950 there were 2.5 billion people on Earth, 30% of which were urban dwellers. A century later, ~70% of the 10 billion global inhabitants are expected to live in cities (United Nations, 2019). In addition to these marked increases in world population and the proportion of city *versus* rural dwellers, city sizes are expanding faster than their populations (Nechyba & Walsh, 2004). Consequently, our planet is and will continue to be increasingly urbanised.

Dramatic growth in city size has led to catastrophic habitat loss worldwide, contributing to the beginning of the sixth mass extinction of biodiversity (Barnosky *et al.*, 2011; Cowie, Bouchet & Fontaine, 2022; Vitousek *et al.*, 1997). Global urban development and lifestyle changes concomitantly cause the loss of human interaction with nature (Miller, 2005; Soga & Gaston, 2016; Richardson *et al.*, 2022), which can negatively impact multiple dimensions of human wellbeing and lead to poor mental health (Bratman *et al.*, 2019; Hartig *et al.*, 2014), with worse outcomes for those with less access to nature (Wolch, Byrne & Newell, 2014). This phenomenon decreases human wellbeing, but also interest in, and empathy and respectful behaviours towards, non-humans (Soga & Gaston, 2016). In this

context, it is important to identify and employ urban actions as pathways to conserve biodiversity, strengthen human–nature connections, and improve wellbeing for all citizens (Abson *et al.*, 2017; Barragan-Jason *et al.*, 2023).

As urban ecology has developed, various ideas have emerged and influenced how scientists can engage in cities. Initially, ecology focused on ecological habitat patches as analogues of non-urban habitats, and viewed the urban matrix as hostile. Other approaches then argued the need to consider biological, social and built urban components from a holistic perspective, and proposed the development of collaborations between researchers, urban actors and residents (i.e. ecology in, of, for and with cities) (Byrne, 2022; Pickett *et al.*, 2016; McPhearson *et al.*, 2016). Today, cities are recognised as complex systems involving interdependencies between social, ecological and technical components (McPhearson *et al.*, 2016), the understanding of which is essential to achieve sustainable objectives (Elmqvist *et al.*, 2019). However, despite calls to integrate knowledge in cities, there remain considerable differences in the perspectives of conservation and social sciences. Conservation approaches, underpinned by the protection of ecosystems, are sometimes carried out without considering local social issues or decision-making systems, which can lead to social injustices and operational limitations (Cumming *et al.*, 2023; Pascual *et al.*, 2021; Robertson & Hull, 2001). Conversely, social and sustainability studies often consider nature in an instrumental and general manner, without considering the diversity of ecological and functional aspects (Botzat, Fischer & Kowarik, 2016). While numerous scientists are calling for a greater coordination of ecological and social sciences to improve biodiversity conservation and social issues (Bennett *et al.*, 2017; Mathevet & Marty, 2020), perfect alignment remains challenging.

First proposed in the late 1980s, rewilding is a strategy for promoting self-sustaining ecosystems by limiting human dominance and control of nature (Carver *et al.*, 2021). Unlike

compositionalist conservation approaches that seek to preserve specific species assemblages, rewilding is a functionalist approach that aims to restore ecological and evolutionary processes with minimal management interventions (Jepson, 2016). Rewilding has mainly been applied and discussed in large areas with low levels of human activity, and in areas where agriculture is in decline (Pereira & Navarro, 2015). Although rewilding in highly anthropised landscapes such as cities raises major socio-ecological questions, it has received much less attention (Massenberg, Schiller & Schröter-Schlaack, 2023). Urban wild spaces can generate aesthetic experiences that are very different from those of tended spaces (Prior & Brady, 2017). A psychological approach is thus critical to investigate the multiple attitudes and experiences of city dwellers with regard to wildness. Wilding cities also poses technical issues for the design and maintenance of urban spaces (Jansson *et al.*, 2020), to establish spatial configurations that simultaneously enable biodiversity conservation and use by city dwellers while aligning with cultural norms (Nassauer, 1995). To be socially just, these choices must consider equity in terms of access to green spaces, and inclusion in the decision-making system (Dempsey *et al.*, 2011).

In this review, we propose a transdisciplinary framework to assess the benefits of urban wilding for biodiversity and people (Fig. 1). We expand on previous studies that have begun to characterise wild spaces in cities and their ecological and social value (Kowarik, 2018; Threlfall & Kendal, 2018). Firstly, we discuss the principles behind the new notion of urban wilding. Next, we summarise the scientific literature to investigate whether and how urban wilding can promote biodiversity, human wellbeing, and people–nature connections in cities. Specifically, our aims are to (i) identify and define the issues associated with urban wilding; (ii) reveal the ecological mechanisms through which urban wilding can promote biodiversity in cities; (iii) investigate the attitudes and relations of city dwellers toward urban

wild spaces; and (iv) discuss the integration of urban wilding into the fabric of cities, and its governance.

## II. URBAN WILDING: PRINCIPLES AND ISSUES

### (1) Rewilding principles

Rewilding is a conservation approach that emerged in the late 1980s as part of the response to the major decline in biodiversity (Soulé & Noss, 1998). The original emphasis of rewilding was on protecting large, interconnected areas for conservation and recovery of large carnivores, as exemplified by the Cores, Corridors and Carnivores (CCC) approach (Soulé & Noss, 1998), but practices have since diversified widely (Carver *et al.*, 2021; Lorimer *et al.*, 2015). Current practices vary according to whether they are based on a historical baseline such as Pleistocene or Holocene epochs, or a non-analogue approach such as novel ecosystems (Lorimer *et al.*, 2015). They also vary according to the initial level of intervention, ranging from active (re)introduction of large herbivores or carnivores (trophic rewilding) (Svenning *et al.*, 2016) to passive rewilding (Fernández, Navarro & Pereira, 2017). With this increase in the diversity of practices claiming to be rewilding, we are seeing the emergence of criticism suggesting that the concept is too plastic and vague to be truly operational (Jørgensen, 2015; Hayward *et al.*, 2019). In order to minimise confusion, a unified concept of rewilding has been proposed, specifying that whatever the practices used, they always refer to the same major objective; promoting the autonomy of natural processes and self-sustaining ecosystems by minimising human intervention (Carver *et al.*, 2021; Massenberg *et al.*, 2023; Prior & Ward, 2016; Gammon, 2018). Furthermore, rewilding practices focus on facilitating functional complexity and the adaptive capacity of ecosystems, rather than on the restoration of a particular state with a predefined species composition (Fernández *et al.*, 2017; Jepson, 2016; Perino *et al.*, 2019).



Another source of criticism of the rewilding concept is that in the original North American proposal, the aim was explicitly to recover wilderness (Noss, 1985). The notion of wilderness, which refers to pristine nature, has been widely criticised for its erroneous vision of landscape history, and its invisibilisation of local historical societies (Cronon, 1996; Callicott & Nelson, 1998). For this reason, references to wilderness have attracted criticism accusing rewilding of excluding human activities, and creating a split between nature and culture (Jørgensen, 2015). Since then, it has been increasingly acknowledged that socio-cultural issues are an integral part of rewilding, and that the aim is to increase the level of wildness (i.e. autonomy of ecological processes) rather than wilderness (Massenberg *et al.*, 2023; Perino *et al.*, 2019). Some researchers have also suggested that promoting the agency of non-human living beings by reducing human dominance over nature does not conflict with improving human wellbeing (Anderson *et al.*, 2019; Prior & Ward, 2016). Finally, rewilding and the quest for wild nature seek to maintain a conceptual separation between nature and culture, but in a dialectical relationship to recognise nature's otherness, rather than dualism (Maris, 2018). It is in this sense that rewilding is an interesting concept for questioning the history of human–nature relations and imagining future cohabitation (Carver *et al.*, 2021; Gammon, 2018; Massenberg *et al.*, 2023).

## **(2) Urban wilding: definition**

Promoting a more autonomous nature means deploying different strategies depending on the socio-ecosystems considered (Carver *et al.*, 2021; Schulte to Bühne, Pettoelli & Hoffmann, 2022). The most anthropised landscapes, such as cities, where social and natural processes intermingle, are probably those where the concept of rewilding has been the least formalised (Drenthen, 2018; Massenberg *et al.*, 2023). Cities are environments that have been heavily modified by and for humans, and a historical ecological baseline that pre-dates cities

is generally unattainable and makes no sense. Instead, we propose urban wilding as a means of achieving better cohabitation between humans and non-humans (Massenberg *et al.*, 2023). This is why, to avoid any confusion, we propose to drop the ‘re’ prefix from ‘rewilding’ and prefer to use simply ‘urban wilding’. To date, the concept of urban wilding has been poorly defined in the scientific literature but can be thought of as the promotion of autonomous ecological processes that are independent of historical land-use conditions, with minimal direct human maintenance and planting interventions (adapted from Lundholm, 2016; Threlfall & Kendal, 2018). From this perspective, an urban brownfield site in which current natural succession processes are untamed by human maintenance could have higher wildness than a national park where continuous maintenance is applied, for example to retain the open character of ecological habitats by removing scrub to favour a particular butterfly species.

Following this meaning, urban wilding can occur on a variety of land-use types, including remnants of agricultural or natural habitats (e.g. forests, wetlands), places where maintenance is intentionally reduced (e.g. ‘wild’ public parks or private gardens), but also in urban spaces without human intentionality (Kowarik, 2011). The latter refers to a diversity of terms in the literature such as informal green spaces, vacant lots, wastelands, brownfields, interstitial sites and ambivalent landscapes [see Farahani & Maller (2019) and Pineda-Pinto *et al.* (2023) for a semantic review]. These spaces vary considerably in terms of size (from small cracks to large areas) and soil type, and can develop on post-industrial, derelict, unattended and transportation-related sites (Kim, Miller & Nowak, 2018; Rupprecht & Byrne, 2014). They have a history of anthropogenic disturbance, are covered in spontaneous vegetation, and are typically home to ‘novel ecosystems’ (Kowarik, 2018; Rupprecht & Byrne, 2014). Depending on the length of time spontaneous vegetation has developed and the type of soil, urban wild areas can be found in different stages of vegetation succession, including sparse vegetation, meadows, shrub thickets and forests (Bonthoux *et al.*, 2014; Chollet *et al.*, 2018; Sitzia,

Campagnaro & Weir, 2016). In our view, given the diversity of urban spaces and their permanent hybridity between human and natural processes, urban wildness should not be thought of as categorical but as continuous along a gradient. Consequently, the issue for conservationists is not to define wild spaces as opposed to others that are not, but rather to recognise that the very diverse spaces which are present in cities vary in their degree of wildness, and this will influence the species assemblages that can benefit from them (Fig. 2).

Urban wilding, which profoundly alters the traditional ways in which cities are represented and function, may generate new socio-ecological issues. For example, the promotion of wild spaces renews everyday urban experiences by modifying aesthetic representations of cities, which can stimulate enthusiasm but also social resistance (Prior & Brady, 2017; Jorgensen & Tylecote, 2007). Urban wilding projects also raise questions of planning, design, governance and public participation to ensure that implementation is adapted to the needs of all communities, and does not cause social injustice (Lorimer *et al.*, 2015). More fundamentally, attitudes towards urban wilding question the social values attributed to nature in cities (Ives & Kendal, 2014). Compared with highly maintained green spaces in which nature has more of an ‘urban décor’ role, the notion of urban wilding brings into debate the intrinsic and relational values of wild nature (Himes & Muraca, 2018). Combined with an ecological understanding, analysis of these social issues is necessary in order to appreciate what urban wilding does to urban socio-ecosystems, but also to assess the capacity to operationalise this concept (Jansson *et al.*, 2020; Soanes *et al.*, 2023).

In the following three sections, we review what is known about urban wilding and its ability to benefit biodiversity and people. To do this, various facets that are traditionally compartmentalised in the scientific literature are addressed and discussed: the ecological processes and biodiversity of urban wild spaces; the relationships between city dwellers and wild spaces; and the articulation of urban wilding with urban planning, governance and

design. Given the wide range of literature assessed, and the absence of a previously accepted common definition and use of the urban wilding concept, we did not carry out a systematic or quantitative review. Instead, we sought to identify and link the main emerging ideas concerning urban wilding from different disciplines.

### **III. HOW URBAN WILDING PROMOTES BIODIVERSITY**

Over the last 30 years, research has revealed that cities can be more than a concrete jungle; they can host a large diversity of non-human organisms, and not only human commensals and parasites (Aronson *et al.*, 2014). With the intensification of agriculture (and forestry), urban areas could even offer an important refuge for biodiversity, and consequently play a significant role in nature conservation (Hall *et al.*, 2017; Ives *et al.*, 2016; Lepczyk, Aronson & La Sorte, 2023). Among the main factors explaining the hosting capacities of cities for biodiversity, direct human interventions, maintenance intensity and the autonomy of ecological processes appear to be essential for controlling the richness and abundance of the majority of non-human organisms from plants to birds, and even microorganisms (Beninde, Veith & Horchkirch, 2015; Mills *et al.*, 2020).

#### **(1) Ecological processes underlying urban wilding**

Urban ecology literature reveals that the number of species able to survive and flourish in urban wild spaces is very high, and often higher than in classically studied urban tended spaces such as public parks and private gardens (Bonthoux *et al.*, 2014; Anderson & Minor, 2017; Müller *et al.*, 2018; Kowarik *et al.*, 2019; Vereecken *et al.*, 2021). Wilding cities by reducing maintenance intensity in urban landscapes appears to be a promising option to promote ecological processes and increase biodiversity, but the underlying processes remain understudied (Groffman *et al.*, 2017). In order to understand potential benefits, approaches

based on assembly rules seem appropriate. Recent reviews based on metacommunity and community assembly theories provide a useful conceptual framework to predict the consequences of reducing the intensity of urban maintenance and increased ecological spontaneity (Andrade *et al.*, 2021; Aronson *et al.*, 2016; Avolio *et al.*, 2021). In order to investigate the consequences for biodiversity, we propose that urban wilding could be divided into two complementary ecological processes: assembly spontaneity and functioning spontaneity (Fig. 2). The former characterises the degree of human intervention in the origin of the studied ecosystem. For example, an urban lawn or a planted forest presents a low degree of assembly spontaneity since most of the species present have been sown or planted. At the other extreme, none of the plants growing on pavements or on wasteland have been actively brought to the specific locality by humans. Functioning spontaneity refers to the amount of human intervention through maintenance. Again, taking lawns as an example, they are intensively maintained (fertilised, frequently mown or irrigated) compared with an urban meadow.

Accumulating evidence in the literature indicates that wilding cities by enhancing both forms of spontaneity in urban green spaces of all kinds (including formal and informal, public and private) increases the amount and diversity of non-human organisms that can survive there.

*(a) Consequences for biodiversity of increasing assembly spontaneity*

The absence or reduction of seed sowing and tree planting in greenspace design can lead to a dramatic increase in local spontaneous plant diversity, as is visible on wastelands (Bonthoux *et al.*, 2014; Kowarik, 2018), in urban woodlands (Conway, Almas & Coore, 2019; Ordóñez & Duinker, 2012), on green roofs (Dunnett, Nagase & Hallam, 2008; Lundholm, 2016) and in ‘gardens in motion’ (Riboulot-Chetrit, Simon & Raymond, 2018). In

habitats with high assembly spontaneity, the soil seed bank and propagule colonisation will reflect the regional species pool, increasing the amount of species potentially growing. After this first step of colonisation, local abiotic filters will be stronger (particularly if pre-treatment of the soil is kept to a minimum during design), and biotic filtering lower due to the absence of competition with sown or planted species (Fig. 3A, B). Consequently, the number of species able to survive in spontaneously assembled communities will be higher than in highly designed ones. In addition, the stronger effect of abiotic filtering will induce higher beta diversity in response to the diversified environmental conditions among sites in the urban matrix. For example, Rebele & Lehmann (2016) demonstrated that spontaneously assembled urban forest on nutrient-poor soil in Berlin was particularly species rich and interesting for conservation. Even in designed and built ecosystems such as green roofs, assembly spontaneity could play a major role in fostering biodiversity since the spontaneous dynamics of plant and insect colonisation may dramatically increase the species richness hosted by the roof (Lundholm, 2016). Nonetheless, in highly mineralised areas or habitats with deeply modified abiotic conditions (e.g. channelised rivers, green roofs, pavements), an initiation phase may be required. In such systems, improving environmental conditions by, for example, improving soil availability, may be a prerequisite for assemblage spontaneity to be effective (Bonthoux *et al.*, 2019b).

*(b) Consequences for biodiversity of increasing functioning spontaneity*

Reducing maintenance is also an important lever to increase biodiversity in cities. With fewer maintenance interventions, species filtering is removed, and this contributes to an increase in biodiversity (Fig. 3C, D). Consequently, more species may establish and expand in habitats where maintenance intensity is low. In the literature, numerous examples demonstrate the positive effects of decreasing maintenance, including reduced mowing frequency of urban

lawns (Chollet *et al.*, 2018) and road verges (O’Sullivan *et al.*, 2017), reduced weeding intensity around tree trunks (Omar *et al.*, 2018) and in cemeteries (Löki *et al.*, 2019), and dead wood preservation in urban woodland (Fröhlich & Ciach, 2020). From a conservation perspective, these measures represent an easy and inexpensive opportunity for maintenance reduction, which in turn leads to a strong increase in taxonomic and also functional and phylogenetic diversity (Chollet *et al.*, 2018). For example, since 2017, a national law has prohibited the use of chemical pesticides in public spaces in France to reduce human health risks. One of the consequences of this law was that city managers were obliged to find alternative weeding systems for pavements which had mainly undergone chemical weeding prior to this regulation. The main choice was to use manual and thermal techniques, but due to the resulting rise in costs, most cities decreased their maintenance intensity. This reduction in weeding intensity has contributed to a significant increase in the diversity of spontaneous plants growing in pavement cracks, with more than 300 species (quarter of the regional pool) recorded in a medium-sized city in central France (Bonthoux *et al.*, 2019b).

(c) *Urban wilding across time and city scales*

Due to the extreme fragmentation inherent in urban habitats, spatial and landscape dimensions are important in cities, potentially controlling the diversity of organisms able to survive (Breuste, Niemelä & Snep, 2008). At the habitat (i.e. patch) scale, the benefit of promoting wildness will always be greater for larger areas than smaller areas (Beninde *et al.*, 2015), but not always feasible due to the different priorities of city planners and designers (see Section V). Nevertheless, increasing wildness at the city scale can promote a multiplicity of species assemblages, and this could contribute to reversing urban biotic homogenisation globally (Bonthoux *et al.*, 2014). In fact, increasing assembly and functioning ecological spontaneity will lead to an increase in the role of local-scale filters (e.g. land-use legacy

effects, different soil and microclimatic conditions, different vegetation ages and successional stages), resulting in high beta diversity (Fig. 3B, D). A high beta diversity between local plots will consequently contribute to higher gamma diversity at neighbourhood and city scales. As well as space, time should be included when considering the benefits of urban wilding. In most habitats, an increase in spontaneity will be more beneficial if it persists over a long period of time. This is one of the reasons why remnant habitats (e.g. urban forest) that persist in the urban matrix are of major interest. These habitats often exhibit both a high degree of assembly spontaneity and a high degree of functioning spontaneity, and have done so for a long time, leading to a capacity to host significant biodiversity, including certain species that are not found in other urban ecosystems (Hahs *et al.*, 2009).

## **(2) Research gaps and potential drawbacks caused by increasing wildness in cities**

Increasing assembly and functioning spontaneity contributes to increasing plant diversity and abundance in all types of habitats, from street pavements to large unmaintained city parks or wastelands. In addition, these gains have cascade effects on fauna, by providing ecological resources for soil organisms (Guilland *et al.*, 2018), insects (Watson *et al.*, 2020), birds (Fröhlich & Ciach, 2020; Threlfall *et al.*, 2016) and bats (Threlfall *et al.*, 2016). However, numerous questions remain unsolved, particularly in understanding the relative roles of both forms of spontaneity for biodiversity. In fact, in most cases, assembly and functioning spontaneity have been studied independently, reducing our ability to predict potential synergistic or antagonistic interactions. We believe that by outlining urban wilding in terms of two explicit ecological processes, our framework will offer the possibility to develop future projects able to bridge this research gap, and provide ecologically informed solutions for city dwellers, designers, managers and planners.



However, one reason why urban wilding, and particularly spontaneous assembly, is avoided in cities is the risk that non-native species may become established, which would potentially be harmful to native biodiversity. Although this can occur, evidence concerning the increase in non-native species in spontaneous assemblages compared with highly designed habitats is scarce and requires more investigation. Although sowing and/or planting of native species may theoretically avoid colonisation through biotic filtering (biotic resistance of functionally similar native species) (Funk *et al.*, 2008), disturbance induced by modifying soil to prepare for planting or sowing may on the other hand promote the establishment of introduced pioneer species (Kowarik, 2008). Some evidence exists for spontaneously assembling urban forest, with a recent study demonstrating that dominance of non-native species in the canopy does not negatively affect native understory plant and insect diversity (Kowarik *et al.*, 2019). In addition, the results of dry grassland restoration projects indicate that seed sowing was not efficient at reducing colonisation by non-native species (Schröder & Kiehl, 2020), and that additional introduced species management is needed. These results suggest that assembly spontaneity does not systematically induce a lower diversity of native plants and/or animals by promoting the installation of non-native species. In addition, recent evidence demonstrates that the beneficial effects of spontaneous non-native plant species could be even greater than those of native sown or planted species for native insect species, as indicated for wild bees (Turo *et al.*, 2021) and pollinators in general (Wenzel *et al.*, 2020). However, it is important to note that the role played by introduced species in spontaneous assemblages and their effects on ecosystem functioning varies greatly depending on the region studied. While the effects are relatively limited in Europe, the situation is obviously very different in regions that have been heavily anthropised only more recently (e.g. Australia, North America) or in ecological systems that are more sensitive to the effects of introduced species (e.g. island systems). There is therefore an urgent need for a systematic

review of the literature to clarify the situations in which urban wilding should be accompanied by efforts to limit introduced species. In addition, research is also needed to clarify the responsibility of cities as non-native species colonisation sources for non-urban habitats. In fact, even if non-native species are not threatening urban diversity, this could be different in non-urban habitats, and consequently urban managers may have a responsibility to avoid non-native species dispersion.

Another case where the benefits of urban wilding should be evaluated is restoration ecology. In most of the examples mentioned above, the main objective was to foster biodiversity, not necessarily to obtain a specific combination of species comparable to a reference ecosystem, as is the case for traditional ecosystem restoration (Clewell & Aronson, 2012). Nonetheless, in urban environments we could, in some situations, intend to promote restoration or rehabilitation of specific ecosystems, which may require stronger interventions (Klaus & Kiehl, 2021). For example, restoration of semi-natural grasslands has been applied on former industrial (Kövendi-Jakó *et al.*, 2019) and military (Schröder & Kiehl, 2020) sites with relatively good success. Such projects usually imply seeding of target species, but also often soil preparation (Klaus & Kiehl, 2021), and not only functioning spontaneity. However, even in habitats targeting a specific community such as lowland meadows or dry grassland, research demonstrates that spontaneous colonisation could be an efficient strategy to increase target species richness (as efficient as sowing), with the added advantage of being very low cost (Sengl *et al.*, 2017; Schröder & Kiehl, 2020). In some cases of restoration (e.g. urban river geomorphology or highly mineralised urban spaces), high-cost interventions will nonetheless be mandatory in order to reset the ecological system, and only after this initial phase could passive wilding be considered an option (e.g. Lewandowsky *et al.*, 2023; Zingraff-Hamed *et al.*, 2017). Further research is needed to evaluate in which cases passive

(i.e. based on wilding) or active (i.e. based on stronger intervention) restoration, or their combination, is the best strategy.

#### **IV. ATTITUDES AND RELATIONSHIPS OF CITY DWELLERS TO URBAN WILDNESS**

In the previous section, we explained how urban wilding can offer a promising means to promote species diversity at different urban scales. However, wilding raises questions about the perceptions of city dwellers in terms of nature in cities. While there is a large body of literature on the relationships between city dwellers and urban green spaces (Ryes-Riveros *et al.*, 2021), studies specifically focused on urban wild spaces are rarer (Botzat *et al.*, 2016). Although urban green spaces generally have positive effects on the wellbeing and health of city dwellers (Beute *et al.*, 2023), these effects can vary depending on biophysical configurations and aspects (Brun, Di Pietro & Bonthoux, 2018; Noe & Stolte, 2023). The shift from ornamental and manicured nature to low-intervention practices significantly changes plant community structure and composition, and alters the visual appearance and urban atmosphere. Resistance to these changes can arise from a lack of alignment between ecological aspects and cultural aesthetic norms (Jorgensen & Tylecote, 2007; Nassauer, 1995; Prior & Brady, 2017). Developing urban wilding thus involves investigating the diversity of city dwellers' attitudes and experiences towards urban wild spaces (Kareiva & Marvier, 2012; Pyron & Mooers, 2022; Pascual *et al.*, 2021). To do this, social science can help describe the diversity of relationships to urban wild spaces, understand the conditions of city dweller's rejection and adherence, and thus align ecological goals with human wellbeing (Bennett *et al.*, 2017; Ernstson, 2013).

In this section, we synthesise what is known about the relationships between city dwellers and urban wild spaces. Although this is an emerging field (Botzat *et al.*, 2016), the

number of studies on this topic is growing rapidly with various epistemological positions and methods (Ives *et al.*, 2017; Moon & Blackman, 2014). We begin this section with a synthesis of people's attitudes and preferences towards urban spaces with contrasting plant configurations and wildness degrees. Studies on attitudes typically adopt an objectivist epistemology, using quantitative methods and large data sets to generalise results and correlate them with socio-demographic characteristics (e.g. Fischer *et al.*, 2020). Second, we examine in depth the different dimensions of relations that are created between city dwellers and urban wild places. For this, we refer in part to studies that draw on subjectivist and phenomenological approaches from humanistic geography (Seamon & Lundberg, 2017), which analyse more qualitatively the lived experiences of urban wild spaces (e.g. Loder, 2014; Noe & Stolte, 2023).

### **(1) Attitudes towards spontaneous vegetation**

In recent years, several studies have been carried out to compare people's attitudes to and visual preferences for different urban plant community structures and successional stages. These studies performed quantitative surveys in the form of online or field questionnaires, based on stimulus photographs or photomontages (e.g. Bonthoux *et al.*, 2019a; Mathey *et al.*, 2018), in front of places with different degrees of wildness (e.g. Brun *et al.*, 2018) or created experimental sites (e.g. Southon *et al.*, 2017).

People were found to prefer urban spaces with herbaceous vegetation, even spontaneous vegetation, over totally mineral spaces on pavements (Bonthoux *et al.*, 2019a; Fischer *et al.*, 2018), tramway tracks (Sikorski *et al.*, 2018) and building walls (White & Gatersleben, 2011). Totally mineral streets were perceived as more boring and less beautiful regardless of the urban landscape context (Bonthoux *et al.*, 2019a). When spontaneous vegetation was present, city dwellers' preferences were strongly modulated by the stages of

plant succession and associated visual aspects. Early successional stages with sparse herbaceous vegetation were disliked. This was particularly the case in vacant lots and brownfield sites with large, sealed surfaces and sparse uneven vegetation in cracks in concrete (Brun *et al.*, 2018; Mathey *et al.*, 2018; Philipps & Lindquist, 2021; Rega-Brodsky, Nilon & Warren, 2018). These places are little used and perceived as spaces pending urban development (Brun *et al.*, 2018). In cities experiencing economic and demographic decline, this type of space may indicate a history of urban neglect (Phillips & Lindquist, 2021).

Grassland stages with tall grass are well liked, and often preferred to frequently mown lawns in both tropical and temperate settings (Hwang *et al.*, 2019; Southon *et al.*, 2017). They are also valued on streets along the edges of pedestrian walkways (Weber, Kowarik & Säumel, 2014) and in vacant lots that are then frequently used by city dwellers (Brun *et al.*, 2018; Hofmann *et al.*, 2012). This aesthetic interest in meadows appears to be related to the perceived visual complexity with heterogeneity in herbaceous plant structure and composition (Lindemann-Matthies & Bose, 2007; Lindemann-Matthies, Junge & Matthies, 2010; Southon *et al.*, 2017; Fischer *et al.*, 2018). Interest in grasslands may be more moderate when they turn brown in late summer, although this is variable among people in different countries (Fischer *et al.*, 2020). Grasslands also show more limited interest than lawns for some recreational needs (Lampinen *et al.*, 2021). Spontaneous shrubby vegetation stages are highly disliked for their tall, dense and untidy appearance, and this seems true in all urban areas (Brun *et al.*, 2018; Mathey *et al.*, 2018; Rega-Brodsky *et al.*, 2018). This vegetation is generally associated with a perception of strong wildness but refers to abandonment and does not facilitate physical access for urban dwellers (Brun *et al.*, 2018; Hofmann *et al.*, 2012). It is probably the successional stage that requires the most mediation support (i.e. by explaining that they are the next forests). Finally, city dwellers show an interest in urban woodlands regardless of their appearance (Lippert, Kowarik & Straka, 2022). They have visual preferences for natural

remnant forest over planted forests, and those in urban parks with strong herbaceous cover management in various geographic conditions (Noe & Stolte, 2023; Lippert *et al.*, 2022).

Recent spontaneous woodlands are least preferred, probably because as with shrubby vegetation stages, they are dense and perceived as unwelcoming (Lippert *et al.*, 2022).

Several studies also explored the correlations between city dwellers' socio-demographic characteristics and preferences for spontaneous vegetation. In particular, people with environment-related jobs or activities, or those with good ecological knowledge, most prefer places with spontaneous vegetation (Bonthoux *et al.*, 2019a; Fischer *et al.*, 2020; Hu *et al.*, 2022; Hwang *et al.*, 2019; Southon *et al.*, 2017). This highlights the importance of increasing direct experiences with natural places and environmental field education to develop people's interest in wild spaces and biodiversity. In several studies, women were more supportive of wild spaces than men (Bonthoux *et al.*, 2019a; Fischer *et al.*, 2020; Lippert *et al.*, 2022). The effects of respondent age are less clear; while in some studies younger people tend to prefer biodiversity-friendly management (Fischer *et al.*, 2020; Lippert *et al.*, 2022), others have found that older people prefer spontaneous vegetation in streets and brownfield sites (Bonthoux *et al.*, 2019a; Mathey *et al.*, 2018). Finally, people's cultural background is also likely to be an explanatory factor, but this aspect remains little explored (Fischer *et al.*, 2020).

## **(2) Relationships of city dwellers to urban wild spaces**

In the previous section, we discussed the preferences of city dwellers for urban green spaces with various plant successional stages. In this part, we further investigate relationships between city dwellers and urban wild spaces. In fact, various geographical and psychological frameworks (e.g. sense of place, place experiences, human–nature connections) assume that people–space relationships result from the encounter between users' activities and

experiences, and the characteristics of the space (Ives *et al.*, 2018; Pramova *et al.*, 2021; Sebastien, 2020). On the basis of these different frameworks, we can identify that these relationships are constructed through at least four interdependent dimensions: users' activities, sensory experiences, affective experiences and cognitive experiences. These dimensions are shaped by the biophysical materialities of spaces, which can be seen as affordances (i.e. opportunities and incentives for certain uses and experiences) (Heft, 2010). In this section, we review city dweller–wild space relationships through these four dimensions, and discuss possibilities to improve attitudes towards urban wild spaces.

*(a) Activities in urban wild spaces*

Activities refer to the behaviours and physical interactions of city dwellers, which may be immobile such as observing or resting, or mobile such as cycling, walking or playing. Increasing and diversifying direct, everyday activities within nature can promote meaningful and cognitive relationships with nature (Barragan-Jason *et al.*, 2022; Soga & Gaston, 2016). As in well-maintained green spaces, urban wild spaces with a few design and maintenance interventions (e.g. paths, small managed areas) allow for recreational uses such as walking and sporting activities (Brun *et al.*, 2018; Farahani & Maller, 2019; Rupprecht *et al.*, 2015). Additionally, wild spaces could provide opportunities and incentives for intentionally interacting with nature (i.e. ecological affordances). For example, ecological richness of such spaces provides opportunities to be more attentive to and observant of wildlife (Noe & Stolte, 2023; Rupprecht *et al.*, 2015). Furthermore, mushrooms and the blossoms, leaves and fruits of wild plants and trees picked in urban spaces can be used for consumption, decoration or medicine as observed in various countries (Garekae & Shackleton, 2020; Landor-Yamagata, Kowarik & Fischer, 2018; Palliwoda, Kowarik & von der Lippe, 2017; Poe *et al.*, 2014). Finally, one study in southern Sweden showed that unmaintained urban spaces increase play

opportunities for children who use plant elements in their activities, such as collecting plant materials, climbing trees and building tree houses (Jansson, Sundevall & Wales, 2016).

Although it seems that urban wild spaces offer interesting opportunities for city dwellers to come into direct contact with nature, these uses become limited when city dwellers have negative attitudes towards these spaces, as explained below.

*(b) Multi-sensory experiences in urban wild spaces*

Regarding sensory experiences, we refer to the five exteroceptive senses (sight, hearing, smell, taste and touch) which are stimulated by the external environment. Some studies and reviews have argued that multi-sensory nature experiences are crucial because they can overcome monotony, provide tranquillity, and create beneficial interactions with nature that cannot be compensated for by virtual environments (Franco, Shanahan & Fuller, 2017; Kjellgren & Buhrkall, 2010). These sensory needs, likely essential for our evolutionary adaptation, struggle to be met in artificial urban landscapes. Despite the very small number of studies in this area, we predict that urban wild spaces have a plant structural complexity and an animal diversity that generates richer sensory experiences than tidy green spaces. The effects of different stages of spontaneous vegetation on visual perceptions were discussed in Section IV.1. Regarding sounds, bird songs and their diversity typically generate positive emotions in urban contexts, with these benefits modulated by the volume, harmonics, frequency and complexity of bird songs (Hedblom *et al.*, 2014; Ratcliffe, Gatersleben & Sowden, 2020). Olfactory perceptions, still largely understudied, are particularly stimulated by advanced vegetation stages. For example, in a study carried out in a New Zealand city, interviewees mentioned the unique smells experienced day and night in bush parks with remnants of native forests (Noe & Stolte, 2023). One English non-urban study showed how olfactory perceptions of forests generate positive emotions and activate personal memories



(Bentley *et al.*, 2022). These perceived odours vary seasonally, with no odours in winter and damp, earthy and mushroom-like odours during the cooler seasons (Bentley *et al.*, 2022). These multisensory experiences amplified by wildness could generate atmospheres that break the stiffness and coldness of very ordered and concrete urban landscapes (Gandy, 2016; Thibaud, 2015). These atmospheres could be spatially contrasted according to the various levels of the stages of plant succession, but also rhythmic in time with the nycthemeral cycles of animal activities, the seasonal cycles of plants, and the interannual dynamics of plant succession. All these expectations need to be explored further in future research. Sensory experiences are difficult to capture and further studies using particular methods such as ethnography are needed to explore the effects of urban wild places.

*(c) Emotions and feelings*

Affective experiences of spaces are narrowly linked to sensory perceptions and include emotions which can be viewed as a combination of valence (i.e. from unpleasant to pleasant situations) and alertness degree (i.e. from tense or excited to boring or relaxed situations) (Hoyle, Hitchmough & Jorgensen, 2017; Russell, 1980). They also refer to feelings such as place attachment or connectedness to nature (Mayer & Frantz, 2004).

Upon contact with green spaces and biodiversity, city dwellers generally feel a sense of calm and happiness, which contributes to recovery of attention from mental fatigue and reduced stress (Hoyle, Jorgensen & Hitchmough, 2019; Marselle *et al.*, 2021; Meyer-Grandbastien *et al.*, 2020). This psychological restoration is linked to a fascination for natural elements, which are visually perceived as more complex than built elements with their rigid lines (Van den Berg, Joye & Koole, 2016). However, not all types of green spaces have the same restorative properties, and it seems that in some cases wild spaces amplify these properties in urban settings. In a New Zealand city, remnant bush parks were superior to lawn

parks for city dwellers to mitigate the stress of urban life (Noe & Stolte, 2023) and in France, less-domesticated natural places contribute the most to psychological wellbeing (Allard-Poesi, Matos & Massu, 2022). These restorative properties could be due to the perception of a high level of biodiversity (Carrus *et al.*, 2015; Bonthoux, Boulay & Voisin, 2023; Fisher *et al.*, 2021). A recent meta-analysis also found that exercise (e.g. walking) in urban wild spaces provides more psychological benefits than in managed spaces (Li *et al.*, 2022). Nevertheless, the results are mixed, and other studies have shown non-significant effects of the level of wildness in urban green spaces on psychological restoration (Van den Berg, Jorgensen & Wilson, 2014)

Some aspects of wild spaces can have negative impacts such as causing anxiety or fear. In particular, wild spaces with a high density of vegetation and low level of clear field of vision may increase the level of stress and be felt as negative to personal safety (Gatersleben & Andrews, 2013; Jansson *et al.*, 2013; Jorgensen & Anthopoulou, 2007), including in some informal green spaces (Rupprecht, 2017). In tall grass, some people fear for their health due to the potential presence of unwanted animals such as ticks or snakes (Farahani & Maller, 2019; Fischer *et al.*, 2020). Urban wild spaces with a high level of plant complexity, and in continuity with agricultural spaces, could attract large mammals such as wild boars that generate fear in some city dwellers (Basak *et al.*, 2022; Conejero *et al.*, 2019). Although not directly related to ecological aspects, illegal activities and anti-social behaviours (e.g. drug dealing and use, dirt bike riding, littering) in some wild spaces lead to feelings of insecurity and rejection among users (Farahani & Maller, 2019). In a perspective of urban wilding development, these negative experiences have to be mitigated by particular design and maintenance practices, as explained below and in Section V.

*(d) Cognitive experiences: the meanings of urban wild spaces*

Cognitive experiences and place meaning, which are highly linked to uses and affective experiences, include descriptive elements such as thoughts, symbols and knowledge that people attribute to a place (Pramova *et al.*, 2021; Sebastien, 2020). Knowing these meanings can help identify what elements of a place people value, and what needs to be preserved and improved in urban landscapes (Masterson *et al.*, 2017).

A number of studies have shown that city dwellers can perceive wild spaces as natural (Brun *et al.*, 2018; Palliwoda & Priess, 2021), providing a home for remarkable animal and plant species (Bonthoux *et al.*, 2023; Noe & Stolte, 2023). A study in Germany showed that informal spaces such as brownfield sites can be perceived as additional green spaces close to houses, and appreciated for their wild aspect (Palliwoda & Priess, 2021). This perception of nature is attenuated and more ambiguous when spontaneous vegetation such as meadows are found on artificial features such as building rooftops in city centres (Loder, 2014).

Perceptions of nature are not necessarily accompanied by significant ecological knowledge, which focuses mainly on common animal species and little on plants (Bonthoux *et al.*, 2023). It is probable that increasing knowledge of urban wild spaces will further increase the affects and positive attitudes towards these spaces (Ienna *et al.*, 2022; Liobikienė & Poškus, 2019). For example, Martens, Gutscher & Bauer (2011) hypothesised that knowing the vital and ecological functions of deadwood might improve attitudes towards urban wild woodlands. Compared with manicured green spaces that mask functional relationships between species, urban wild spaces present important educational opportunities for developing attention and knowledge about biodiversity and interdependencies between species (Levé *et al.*, 2019; Mengual & Morizot, 2018).

Urban wild spaces are also perceived by some users as escapes from the city (Noe & Stolte, 2023). In particular, informal spaces can be perceived as spaces of freedom, with an

absence of local government control that allows escape from city order – a free space for improvisation and appropriation by people (Farahani & Maller, 2019; Foster, 2014; Gandy, 2016; Jorgensen & Tylecote, 2007; Noe & Stolte, 2023; Rupprecht *et al.*, 2015). For example, a decommissioned former railway line around Paris, where unmaintained plant succession is underway, is frequently used by young people, homeless people, walkers and artists to escape the conventional codes of comfort and beauty of urban parks and gardens (Foster, 2014). Urban wild spaces can thus be seen as a means of developing the imagination and cultivating a sense of exploration and creativity through an informality that goes beyond our mental framework and will (Farahani & Maller, 2019; Gandy, 2013). In particular, in these spaces children can invent their own games and make the place their own (Jansson *et al.*, 2016).

More negative thoughts can also be attributed to urban wild spaces. In particular, informal spaces can be perceived as abandoned and neglected by the community (Jorgensen & Tylecote, 2007; Riley *et al.*, 2018), especially those with a dense vegetation structure or littering (Brun *et al.*, 2018; Farahani & Maller, 2019; Palliwoda & Priess, 2021). These perceptions of city dwellers refer to negatively connotated terms such as empty lots, brownfield sites or wastelands often used in planning and academic literature to designate wild informal spaces (Farahani & Maller, 2019). Some authors propose more neutral terms such as unintentional spaces (Gandy, 2016). The association between neglect and spontaneous vegetation is also found among some private garden owners who aim to maintain well-kept gardens with an orderly aesthetic (Riboulot-Chetrit *et al.*, 2018).

*(e) Small interventions can mitigate negative attitudes and experiences*

A number of studies have shown that small and inexpensive design and maintenance interventions can significantly improve uses, affects and attitudes towards urban wild spaces. The accessibility of spaces and availability of facilities (e.g. small paths, benches, light sports

facilities) are important parameters for encouraging the use of the site by a variety of city dwellers, and showing that even sites with a wild appearance remain welcoming to people (Hofmann *et al.*, 2012; Palliwoda & Priess, 2021; Unt & Bell, 2014). Litter collection is also a key element in improving attitudes (Farahani & Maller, 2019; Palliwoda & Priess, 2021; Rupprecht *et al.*, 2015). Finally, specific vegetation maintenance actions such as well-marked delineation of spontaneous vegetated areas through regular mowing can be applied to improve perceptions and promote aesthetic acceptance (Bonthoux *et al.*, 2019a; Hwang *et al.*, 2019). Furthermore, some visual openings and wide walkways can decrease the perception of unsafety (Gatersleben & Andrews, 2013; Jansson *et al.*, 2013). Together, these small interventions can mitigate the socially negative effects of wildness, and can be included in urban design (Section V).

### **(3) Research gaps**

As mentioned above, social studies dealing specifically with urban wild spaces are emerging, but more work is required to identify the conditions promoting synergies between biodiversity conservation and people's wellbeing through urban wilding. To this end, we propose several avenues of research. First, cities are composed of a variety of spaces with contrasting uses, forms and ownership status (e.g. historic city centres, industrial and commercial zones, residential areas with detached houses, large housing estates) (Oliveira, 2022), but knowledge about differences in wildness perceptions between these urban contexts remains scarce. In particular, industrial areas and housing estates should be investigated because they can cover vast areas and house a large population of workers and residents. Second, most studies on the perceptions of urban wild spaces have been conducted in the global north, similar to biodiversity or green space perception studies (Botzat *et al.*, 2016; Reyes-Riveros *et al.*, 2021). The effects of contrasting perceptions between various cultural backgrounds and

ethnicities remain largely under-researched (Botzat *et al.*, 2016; Buijs, Elands & Langers, 2009), even though this knowledge is necessary to align actions with local people's needs. Finally, urban wild spaces can take different aspects depending on climate, with development of shrubs or forests in temperate, tropical or boreal biomes but sparse xeric vegetation in arid regions. In these regions, where urban practices aim to intervene heavily to plant and maintain vegetal aspects with trees and lawns (Larsen & Harlan, 2006; Reyes-Paecke *et al.*, 2019), a fairly strong rejection of the appearance of urban wild spaces could be expected, but this remains to be assessed.

## **V. URBAN WILDING IN THE FABRIC OF JUST CITIES**

In previous sections, we considered the effects of urban wildness on biodiversity and the experiences of city dwellers. Taking into account certain ecological and social limitations (e.g. managing invasive species, reducing negative perceptions of insecurity and abandonment), the promotion of urban wild spaces appears to be a promising way of establishing desirable links between humans and nature. However, establishing wild spaces in cities is not straightforward and involves disruption alongside urban technical and policy innovation (Moore *et al.*, 2014). This means finding subtle and contextual solutions to meet both the challenges of biodiversity conservation and socio-technical issues (Maller, 2021). In particular, the aim is to examine how wildness can be integrated into the strategic management process of urban green spaces, which involves a complex system of public and private actors and comprises an iterative cycle of stages including planning, design, construction and maintenance (Jansson *et al.*, 2020; Dempsey & Burton, 2012). Throughout this process, questions arise about visions and values of nature in cities, urban practices and techniques, as well as issues of governance, social inclusion and transdisciplinarity (Albert *et al.*, 2021; Kabisch, Frantzeskaki & Hansen, 2022). All decisions can have significant

consequences for biodiversity and for the experiences of local populations (Fig. 1). In the following parts, we synthesise and discuss the ways in which urban wilding renews visions of human–nature relationships, and how wildness can be integrated into the various stages of urban space management. For the sake of clarity, we deal with these stages in succession, even though the actors involved interact frequently.

### **(1) Urban wilding to promote human–non-human cohabitation**

The notion of urban wilding and its evocative power has the capacity to question human–non-human relationships, and to debate new visions of future cities (Pineda-Pinto *et al.*, 2023). Especially in the developed world, cities have historically been thought of as places built by and for humans. Vegetation in cities has long been considered largely as ornamental and structural elements (Mathis & Pépy, 2017). Since the industrial revolution and urban expansion during the 19th century in western Europe, vegetation and green spaces have been employed as a solution to urban nuisance and pollution (Mathis & Pépy, 2017; Cormier, 2015). Since the 1960s, with the environmental crises, ecological concepts and principles have gradually emerged and been integrated into urban planning and design (Heymans *et al.*, 2019). However, even though planning now has a strong environmental agenda, urban actions are still often guided by an anthropocentric vision (Pineda Pinto, 2020). Even so, new ethical thinking is emerging about the roles and responsibilities of humans and other species in cities. A growing body of ‘more than human’ research is challenging the anthropocentric and technocentric perspectives of theories and practices of urban creation (Franklin, 2017; Houston *et al.*, 2018; Maller, 2021; Yigitcanlar, Foth & Kamruzzaman, 2019; Van Patter, 2023). These works highlight the interconnections between humans and other species in the city, and argue that non-humans should be considered co-constitutive actors participating in the governance of urban planning and design (Hernandez-Santin *et al.*, 2023; Houston *et al.*,

2018). On this basis, some assert the need to recognise all forms of life, and to develop multi-species justice, to guide the future of urban spaces (Fieuw, Foth & Caldwell, 2022; Pineda-Pinto *et al.*, 2023).

By promoting the autonomy of ecological processes and species, urban wilding is part of this approach, and aims to improve human–non-human cohabitation in cities. Urban wilding differs from other concepts such as ecosystem services, nature’s contributions to people or nature-based solutions, which have been criticised for their instrumental visions of nature that do not promote deep cultural and structural changes in human–nature relations (Bekessy *et al.*, 2018; Mercado *et al.*, 2024; Muradian & Gómez-Baggethun, 2021; Piccolo *et al.* 2022; Randrup *et al.*, 2020). As well as providing benefits for humans through foraging (Garekae & Shackleton, 2020) and especially climate regulation (Robinson & Lundholm, 2012), urban wild spaces may be opportunities to draw the attention of city dwellers to the different ways of living in cities, and engender respect for non-human living things (Maris, 2018). By generating affective and cognitive experiences of nature (Section IV), wild spaces also have the potential to develop relational values of nature such as spiritual and aesthetics experiences and ecological knowledge (Chan *et al.*, 2016; Himes & Muraca, 2018). It has been suggested that relational values can serve as leverage points for changes toward nature connection and conservation actions (Bekessy *et al.*, 2018; Mattijsen *et al.*, 2020; Russo Lopes & Bastos Lima, 2023; Uehara, Sakurai & Hidaka, 2022). We can therefore expect the development of wild urban spaces in urban planning to be a pathway for improving human–nature connections. However, cities are and will remain first and foremost places for human activities, which means that urban wilding must be linked to social issues in planning and design.



## **(2) Wilding, planning and social inclusion**

Urban planning involves political, regulatory and technical activities that spatially organise cities in order to achieve social, economic and environmental objectives from the agglomeration to the neighbourhood scale. We discuss below how wilding can be integrated into urban planning by characterising its deployment in the urban landscape, and discussing the governance and social issues to be considered for its development.

### *(a) Planning with wildness*

Many cities have developed strategies for biodiversity conservation, but the level of precision of local objectives could be improved (Nilon *et al.*, 2017). Based on the ecological and social potential summarised in the previous sections, we propose that wilding could form part of ecological planning strategies. With its qualitative and functional objectives, it could complement policies aimed at increasing the quantity and continuity of green spaces. Wilding has been used in particular in the planning of two cities with contrasting historical contexts and configurations. In Knoxville, Tennessee (USA), a set of large parcels with various previous land uses and belonging to various public and private owners has become a network of wild parks covering 668 ha (Zefferman *et al.*, 2018). The project was initially championed by a local not-for-profit group in the 1990s. The majority of visitors live nearby, come to walk or cycle, and appreciate the minimal maintenance of vegetation. A major challenge for this project is to coordinate the management of these parks with the various owners. Parts of Berlin, the capital of Germany and the site of the Berlin Wall, a section of the former Iron Curtain that separated the political ‘east’ and ‘west’ in Europe, have been reconfigured to become a greenway linking the urban centre to its outskirts (Kowarik, 2019). This green structure is unique in that it successfully combines the preservation of the site’s memory with the preservation of the remains of walls and historical information, and the use of wildness

and natural succession in the design of several parts of the greenway. This successful integration of wildness into Berlin's planning was facilitated by long-term cooperation between scientists and planners (Lachmund, 2013). Urban wilding can be integrated into the planning of cities of all sizes, and small municipalities are also putting wilding at the heart of their environmental policy to design urban public spaces (see Fig. 4 for an example in France).

*(b) Roles of informal green spaces*

Even though they are often small and sometimes temporary, the various types of informal spaces (e.g. vacant lots, street verges) (Kim *et al.*, 2018; Rupprecht & Byrne, 2014; Stanford *et al.*, 2022) can cumulatively cover large surfaces on a city scale, and participate in an overall urban wilding strategy. For example, in Melbourne, Australia, road easements account for more than a third of public green spaces (Marshall, Grose & Williams, 2019). In cities in demographic decline such as Detroit, USA, vacant lots can cover very large areas (Nassauer & Raskin, 2014). In addition to their ecological interest, the ubiquitous character of informal spaces can afford them an important role in increasing access to wild nature, particularly in the political context of compact cities (Palliwoda & Priess, 2021; Stanford *et al.*, 2022). Due to their proximity to residential locations, they are regularly frequented by urban residents for a variety of recreational activities (Brun *et al.*, 2018; Rupprecht *et al.*, 2015; Palliwoda & Priess, 2021). In addition to their ecological interest, informal spaces can thus complement formal green spaces and reduce distributional inequality in access to nature (Draus *et al.*, 2020), especially for the most vulnerable people such as children or the elderly, (e.g. in Łódź and Warsaw, Poland) (Sikorska *et al.*, 2020). Through an 'urban acupuncture' approach, some cities have developed temporary use programmes for wild vacant lots and brownfield sites to revitalise neighbourhoods, which requires a communication strategy and minimal

maintenance of these sites (Naghbi & Faizi, 2022; Rall & Haase, 2011; Unt & Bell, 2014). However, the ecological and social potential of informal spaces is often largely overlooked in planning and poorly integrated in urban strategies, documents and maps (Biernacka *et al.*, 2023; Cox & Rodway-Dyer, 2023; Stanford *et al.*, 2022; Unt, Travlou & Bell, 2014). For example, in a study on 19 informal wild woodland sites distributed in 13 Italian cities, more than half of the sites were not recognised in urban documents, and were destined for conversion into new sealed areas or tree plantations (Trentanovi *et al.*, 2021a). In fact, in cities undergoing demographic growth, vacant lots and associated socio-ecological opportunities are often under pressure from competing economic endeavours focused on profitability and urban redevelopment (Cox & Rodway-Dyer, 2023).

### *(c) Governance and inclusion*

Implementing urban wilding involves questioning and anticipating the associated modes of governance (i.e. the arrangement of various public and private actors in the decision-making process) (Jansson *et al.*, 2020). There are various forms of urban governance, from top-down planning approaches to civil society initiatives. Regarding other urban green spaces, to implement urban wilding, hybrid, collaborative or mosaic governance approaches involving long-term collaborations between local governments and community initiatives could contribute to fair and sustainable changes (Buijs *et al.*, 2019; Frantzeskaki, 2019; Toxopeus *et al.*, 2020). In particular, to ensure that the implementation of wilding is adapted to local needs without imposing external visions of nature, it is important to implement these measures with concern for social recognition and inclusion (Albert *et al.*, 2021; Kabisch *et al.*, 2022; Tozer *et al.*, 2020). To achieve this, local authorities can mobilise various participatory approaches to include citizens in the decisions taken during the various phases of strategic management of urban public spaces (Fors *et al.*, 2021). The initiative can also come from civil society itself,

members of whom can play a fundamental role in the recognition and enhancement of informal wild spaces. An Italian study shows how four former industrial and military sites, where spontaneous vegetation has been growing for over 20 years, have been turned into sites of ecological interest and recreational use by various socio-environmental movements (Trentanovi *et al.*, 2021b). These movements are made up of a network of informal actors including citizen groups and formal actors such as non-profit associations with official status. The mobilisation of communities in these areas has made it possible to change the institutional public discourse on the ecological roles of these areas, while empowering these communities in terms of socio-cultural identity, social relations and power to negotiate with institutions (Trentanovi *et al.*, 2021b). With the aim of scaling up, the various local citizen actions can be integrated into a mosaic governance network that is animated and coordinated by local government to facilitate spaces for deliberation (Buijs *et al.*, 2019). Inclusive approaches in the implementation of wilding do not only concern civil society, but must also extend to all municipal actors at different hierarchical levels. Care must be taken to ensure that the promotion of new ecological policies does not lead to a restructuring of modes of governance and management that degrades the conditions of workers (Ernwein, 2022). It is therefore important that ecological policies in favour of greater wildness are aligned with the wellbeing, organisation and practices of field workers (Deparis *et al.*, 2023).

### **(3) Designing urban spaces with wildness**

Urban designers (i.e. architects and landscape architects) design at building, plot, city block and neighbourhood scales by integrating urban political goals, social issues (i.e. local uses, mobility, social cohesion, aesthetic), environmental objectives, and regulatory and technical constraints. Urban design choices strongly influence everyday immersive experiences of nature in cities. With its changing and unexpected aesthetics (Prior & Brady, 2017), wildness

can provide opportunities to renew urban design, aligned with local cultural norms and political expectations (Nassauer, 1995; Gobster *et al.*, 2007). Whereas traditional practices of designers were interventionist and anthropocentric, emerging approaches aim to design spaces that are habitable by humans and other species at both landscape and building scales (Bracke *et al.*, 2022; Grobman *et al.*, 2023). Designing with spontaneous vegetation (i.e. favouring assembly spontaneity) can open up new avenues for landscape architecture by allowing the expression of ecosystem dynamics and taking advantage of regional ecological singularities (Hwang & Yue, 2019; Kowarik, 2021; Teixeira, Fernandes & Ahern, 2021). By creating pleasing spatial configurations that highlight and draw attention to wild spaces (Buyck, 2019), urban design can be a key step in developing human–nature connections in cities.

Gilles Clément was among the first landscape architects to design gardens and parks incorporating wilding in France from the 1980s onwards (Clément, 2006; Gandy, 2013). He presents his ‘garden in movement’ approach as a political act in defence of living things, in which garden forms are not the result of aesthetic cultural norms but of a preference for wild plant dynamics. With this approach, he asserts that the landscape gardener’s role is that of observer and interpreter, supporting natural processes and living things. Similar design approaches are being developed in various places including Singapore, where designers use the notion of ‘intended wildness’ (Hwang & Yue, 2019). Wilding is now being used in many different types of design at various urban scales (Fig. 5).

In practice, to reconcile ecological and social issues, the designer must find a subtle combination between wild areas and some occasional interventions such as a few planted spaces, built elements or urban facilities to welcome users and guide perceptions. For example, in a wild park, the designer could choose to use wooden fences and benches, and plant a small orchard so that the site evokes both nature and the countryside (Aggeri, 2016). To limit insecurity and the perception of abandonment, and to facilitate movement and certain

uses such as sport or picnics on the grass, paths can be laid out in the meadows, small areas can be maintained as lawns, and shrubs can be pruned occasionally (Noe & Stolte, 2023; Unt & Bell, 2014). Thinning of vegetation can be carried out to maintain certain panoramic views of cultural and architectural elements that mark the history of the city. Designing with spontaneous vegetation also involves technical considerations. As vegetation, and urban trees in particular, are under threat from climate change (Esperon-Rodriguez *et al.*, 2022), replacing nursery planting with spontaneous vegetation can enable the natural selection of plants that are better adapted to the edaphic and climatic conditions of cities, and that do not require irrigation in the first few years after planting (Kühn, 2006). The use of spontaneous vegetation therefore has the advantage of not requiring any inputs or energy consumption to produce and maintain the plants. However, spontaneous vegetation succession takes time, and in some cases, planting may be necessary to structure the space and provide an immediate visual impact. In areas that have been mineralised by previous development (e.g. town squares, school grounds and wide pavements), the concrete can be removed to allow vegetation to colonise and develop spontaneously. Where this development is too uncertain (for example, in isolated spaces and areas with no soil and/or seed bank), soil can be added to accelerate plant development. In the design of buildings, architects and engineers are working on the development of walls and roofs with new materials that allow the spontaneous colonisation of plants and animals (Grobman *et al.*, 2023; Lagurgue, Mayrand & Clergeau, 2019; Madre *et al.*, 2014). Given that the perceptions and political roles of urban spaces differ according to context (e.g. historic and heritage city centre *versus* peripheral parks), this means adapting and imagining designs with different degrees of wildness according to the various urban morphologies.

#### **(4) Maintenance**

Maintenance of urban spaces, often carried out by municipal services, is closely linked to local urban policy strategies. It follows the design and construction processes and is crucial to the long-term sustainability of projects, even if its importance is often undervalued (Duivenvoorden *et al.*, 2021; Dempsey & Burton, 2012). With regard to the maintenance of green spaces, pruning, mowing and cleaning activities have a direct influence on the level of functioning of ecological spontaneity (Section III). In some countries, the role of spontaneous vegetation in maintenance strategies is changing. For example, a French national law banning pesticides in cities has profoundly altered municipal maintenance practices regarding urban spontaneous vegetation in grey spaces such as street sidewalks (Deparis *et al.*, 2023). Implementation of such laws is under debate by the European Union (<https://www.pesticide-free-towns.info/>). In addition, the practice of differentiated maintenance of public urban green spaces has been developing since the 2000s in several European countries to meet the challenges of budget savings, adaptation to user demands and aesthetic and ecological intentions (Aggeri, 2004; Ernwein, 2022; Oosterhuis, 2014). In this approach, green spaces have different maintenance intensities (e.g. mowing between one and 15 times per year) depending on their locations and roles in the city. Different maintenance intensities can also be applied within the same urban space. For example, in a large Jewish cemetery in Berlin, a mosaic of maintenance intensities enables cultural elements to remain visible and different ecological habitats to develop (Kowarik *et al.*, 2016). These changes can be accompanied by evolution of maintenance professions traditionally based solely on vegetation control towards greater ecological attention, and the development of observation and monitoring skills (Arpin, Charvolin & Fortier, 2015; Legrand & Martin, 2018).

To make these changes easier and facilitate the adoption of new practices by municipal services, a number of aspects need to be considered. Promoting minimal maintenance of

green spaces may require the renewal of some equipment; tools for mowing tall vegetation meadows and pruning shrubs need to be robust and are not the same as those dedicated to the upkeep of regularly maintained spaces. This technical element needs to be considered because it can act as a financial and organisational brake on change (Deparis *et al.*, 2023).

Maintenance changes may also lead to field workers fearing negative perceptions of residents with whom they interact on a daily basis (Nam & Dempsey, 2019). To avoid such barriers and limit the burden on field operatives, a clear political municipal discourse towards inhabitants about new ecological strategies is required.

#### **(5) Wildness in urban private spaces**

Local public policies and associated planning measures can impact public urban spaces, but much less frequently impact private green spaces in residential, commercial and industrial sectors. Among the actors who intervene in private spaces, real estate developers have a strong influence in buying, improving and selling property. They impact urban form and function, particularly in residential neighbourhoods, but they are still a long way from integrating green considerations into their practices (Turner, 2017). The standards and practices of the real estate development industry, combined with market economics and regulatory constraints, tend to severely limit innovation and the place of ecology in these urban sectors (Turner, 2017). A crucial issue is therefore to identify regulatory, financial and institutional levers to bring biodiversity preservation and wildness into the practices and interests of these private actors.

In addition, wildness can develop in residential gardens, which can cover more than half of the urban area (Gaston, Ávila-Jiménez & Edmondson, 2013). In these spaces, homeowner attitudes towards wildness vary dramatically, depending on how a family uses their garden and the impacts of surrounding developments (Home *et al.*, 2019). The



motivations of homeowners to move towards biodiversity-friendly practices are modulated by individual interests and moral values, but also are strongly influenced by neighbourhood-scale social norms that can be barriers or facilitators in changing practices (Goddard, Dougill & Benton, 2013). Moreover, industrial spaces, which cover large urban areas, have largely been ignored in previous studies (Serret *et al.*, 2014). All management decisions in these private spaces are individual, and made by a large variety of actors, with a potential spatial dispersion of biodiversity-friendly practices (Aronson *et al.*, 2017). The challenge is to find a stewardship system that coordinates practices to achieve large-scale beneficial ecological effects while accommodating the diversity of private practices and lifestyles (Cerra, 2017). Given the importance of private land in the city, a major effort of both municipalities and associations must be a priority to promote practices that encourage wildness.

#### **(6) Scientist–actor partnerships in experimental urban wild designs**

In the previous sections, we synthesised research *on* urban actors and their practices with regard to urban wilding. Here, we discuss how scientists can work *with* actors to accompany the wilding process and monitor its implementation. Several works suggest that transdisciplinarity, which consists of close collaboration between scientists and non-scientists in the creation of new knowledge (Tress, Tress & Fry, 2005), is a success factor of socio-ecological sustainability (Albert *et al.*, 2021; Frantzeskaki *et al.*, 2020; Lang *et al.*, 2012). Transdisciplinary co-production is context based and goal oriented (Norström *et al.*, 2020), and its implications vary from researching solutions and empowering actors to reframing agency (Chambers *et al.*, 2021). In an urban context, such approaches are referred to as ‘designed experiment’ (Felson, Bradford & Terway, 2013), ‘research by design’ (Roggema, 2017), ‘research through designing’ (Lenzholzer, Duchhart & Koh, 2013) and ‘learning by doing’ (Ahern, Cilliers & Niemelä, 2014). These approaches, which follow an iterative cycle

of problem diagnosis, intervention, monitoring and evaluation, and reflective learning, can help to develop evidence-based planning and design, and enter into a process of adaptive design (Ahern *et al.*, 2014; Brown & Corry, 2011) (Fig. 1). To ensure that ecological ambition meets the local social desire of residents, a participatory approach can be implemented (often referred to as participatory action research). The combination of these approaches can thus resolve the tensions between scientific credibility, relevance to decision-making, and respect for local values (Nassauer & Opdam, 2008).

Such a transdisciplinary approach is being used in a wilding study in Blois, a medium-sized town in central France, and a long-term study site of the LTSER Zone Atelier Loire, CNRS. This study aims to identify urban spatial configurations with wild spaces that meet user requirements, and to analyse how the process of collaborative and participatory wilding modifies relations between the actors involved. This study is being carried out in the maintained green spaces of two large housing estates (see online Supporting Information, Figs S1 and S2). In 2021, interviews and observation of usage revealed that residents were indifferent to biodiversity in the large green spaces in these neighbourhoods, and that they participated in few activities in these spaces. In 2022, a collaborative design process was initiated involving scientists, elected representatives, municipal services and landscape architects. Through interviews and focus groups, residents were able to react at various stages to the scenarios proposed for the site's evolution. Since autumn 2022, a new landscape design based on spontaneous shrub areas and natural meadows sown by local children has been implemented on the large lawns of these spaces. Immersive paths and small street furniture have been installed to encourage residents to interact with nature. Ecological communication campaigns will be organised with municipal services for local schools and residents. In 2026 and beyond, once the vegetation has developed, interviews with residents will once again be carried out to assess their changing experiences and attitudes towards nature and wildness. In

this type of project, scientists are producers of knowledge, but they are also agents of change and intermediaries between actors with different perspectives and knowledge (Kruijf *et al.*, 2022). The development of this type of approach requires long-term longitudinal studies combining different paradigms of knowledge acquisition through the different stages of the process (post-positivism, constructivism and advocacy/participation) (Cortêsão *et al.*, 2020). In addition, it involves establishing a relationship of trust between scientists and municipal urban actors in order to balance the priorities of practice (urban policy, technical constraints, legislation) and research (scientific validity, impartiality and reproducibility) (Pataki *et al.*, 2021).

## VI. CONCLUSIONS

(1) Herein, we propose and define the notion of urban wilding and investigate its propensity to improve biodiversity and people–nature connections. Through an interdisciplinary synthesis, we explore the ecological mechanisms through which urban wilding can promote biodiversity in cities, investigate city dwellers’ attitudes and relations towards urban wild spaces, and discuss the integration of urban wilding into the fabric of cities and its governance.

(2) Locally, favouring assemblage spontaneity by reducing planting interventions, and functioning spontaneity by limiting maintenance practices promotes plant diversity and provides ecological resources for many animals. At the city scale, urban wilding promotes a wide range of habitats and organisms, and could help to reverse the biotic homogenisation caused by urbanisation. Nevertheless, further studies are needed to understand the effects of urban wilding on invasive and native communities.

(3) The attitudes of city dwellers towards spontaneous vegetation are modulated by successional stages, with grassland and woodland stages preferred and dense shrubby

vegetation stages disliked. Wild spaces can diversify physical interactions with nature, and enrich multi-sensory, affective and cognitive experiences of nature in cities. However, some aspects of wild spaces can cause anxiety, feeling unsafe, and the perception of abandonment. These negative attitudes could be mitigated by small design and maintenance interventions.

(4) While urban nature has long been thought of as ornamental and instrumental, urban wilding could help to develop relational and intrinsic values of nature in the fabric of cities. Wildness and its singular aesthetics can renew urban design and should be combined with cultural norms, residents' uses and urban functions to create urban configurations promoting human–non-human cohabitation. For urban wilding to be socially just and adapted to residents' needs, its implementation should be backed by inclusive governance opening up discussion forums to citizens and all urban workers. Scientist–urban actor partnerships should be developed to experiment with and design new wild spaces promoting biodiversity and human wellbeing in cities.

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## IX. SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**Fig. S1.** Experimentation of socio-ecological transformation, based on urban wilding and a participatory research by design approach.

**Fig. S2.** Longitudinal method used in the experimentation of socio-ecological transformation at the two sites shown in Fig. S1.

### Figure legends

**Fig. 1.** Transdisciplinary framework showing how increasing urban wildness in the fabric of cities may promote biodiversity and people–nature connections in urban landscapes. This dynamic is iterative, initiated and evaluated through a collaboration between urban actors and (natural and social) scientists.

**Fig. 2.** Decomposition of the two dimensions of urban wilding (i.e. functioning and assembly spontaneity) with examples of urban ecological habitats.

**Fig. 3.** Schematic representation of species filtering from the city species pool to local assemblages with low (A, C) and high (B, D) ecological spontaneity. Different colours represent different species, with hatched symbols indicating species selected (seeded or planted) by humans. When assembly spontaneity is low (A), the dispersal filter is partly suppressed because humans select the same few species from the cultivated species pool to seed or plant. These few species are usually highly competitive, increasing the biotic filtering of communities. By comparison, when assembly spontaneity is high (B), dispersal filtering induces a more heterogeneous sorting of species. Because there is no intentional soil

preparation at the sites, abiotic filtering is higher than in the case of low assembly spontaneity. Low functioning spontaneity (C) is characterised by strong maintenance filters, conducive to the selection of the same tolerant species. Conversely, when functioning spontaneity is high (D), few species are filtered by maintenance, increasing the role of abiotic and biotic filters on the local assemblage, eventually increasing hosting capacities and heterogeneity (beta diversity).

**Fig. 4.** Saint Lunaire, a small town of 2500 inhabitants located in the North of France on the Channel coast, is implementing an ecological policy partly based on wildness to plan public and private spaces: (A) a public garden in the town centre, combining a regularly mowed play area and a space mowed every 3 years, accompanied by educational panels; (B, C) a town entrance landscaped in 2019, with a grassy layer not sown and mowed once a year; (D) a panel at the entrance of 120 private gardens participating in the ‘Jardins Bio-Divers-Cité’ program, which aims to support changes in individual practices in private spaces. Photograph © S. Bonthoux.

**Fig. 5.** Examples of French urban designs at different scales integrating wildness. (A) Urban forest in Prairies Saint Martin, Rennes (© S. Bonthoux); (B) EcoVillage des Noés, Val-de-Reuil (© APM Architectur); (C) Ile Mabon square, Nantes (© JD. Billaud / Samoa); (D) Jean Lenine street, Saint-Denis (© DR); (E) roof landscaped with soil to host spontaneous vegetation, Paris (© Topager); (F) prototype walls to accommodate spontaneous vegetation, Paris (© Agence ChartierDalix).

Fig. 1

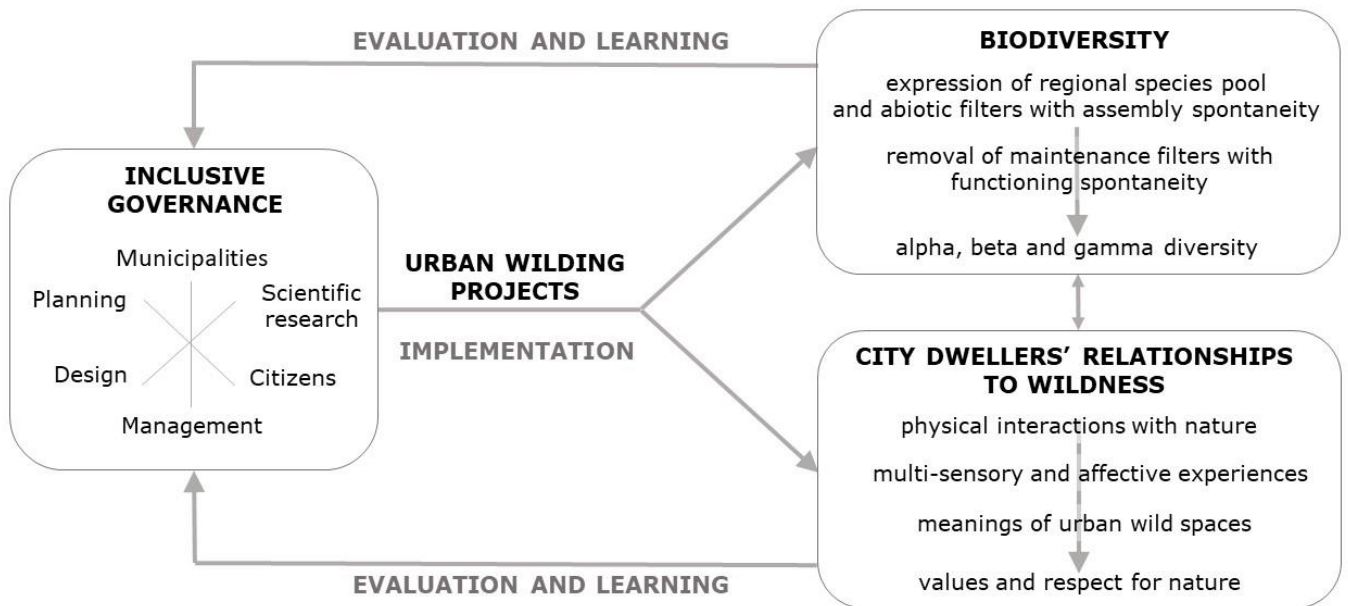


Fig. 2

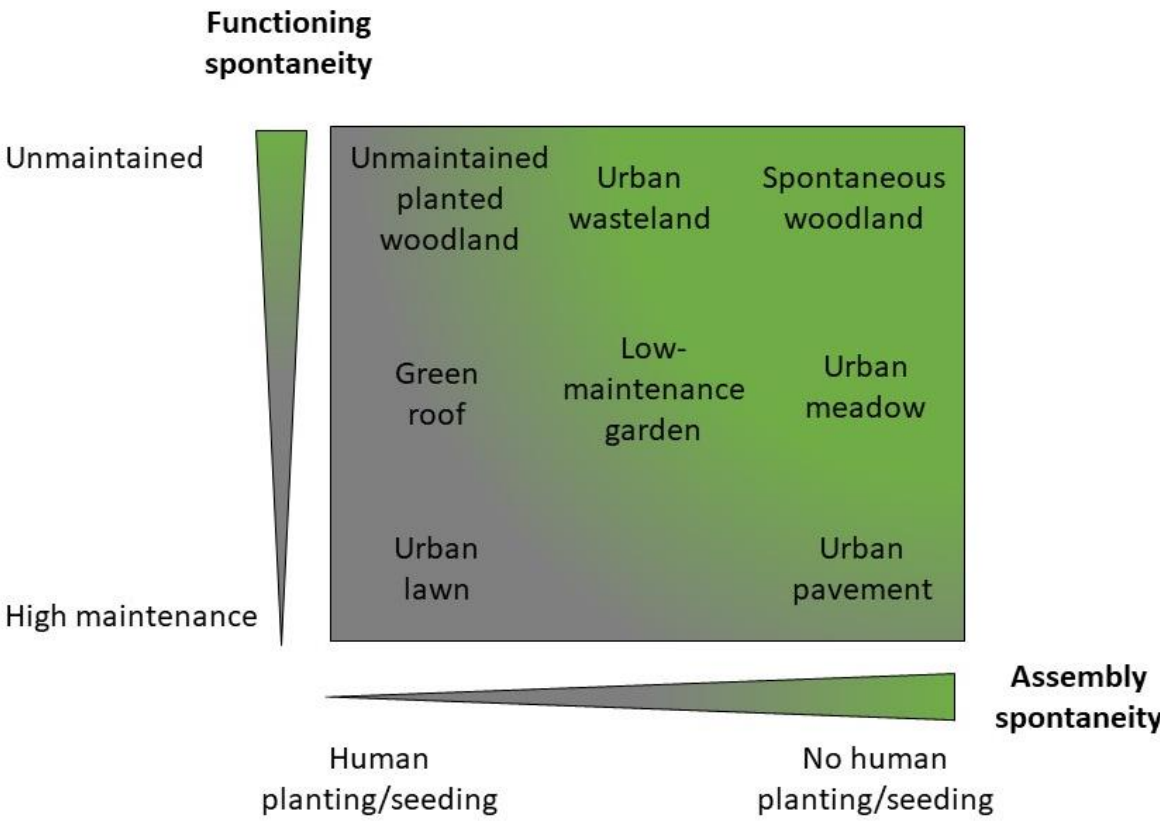
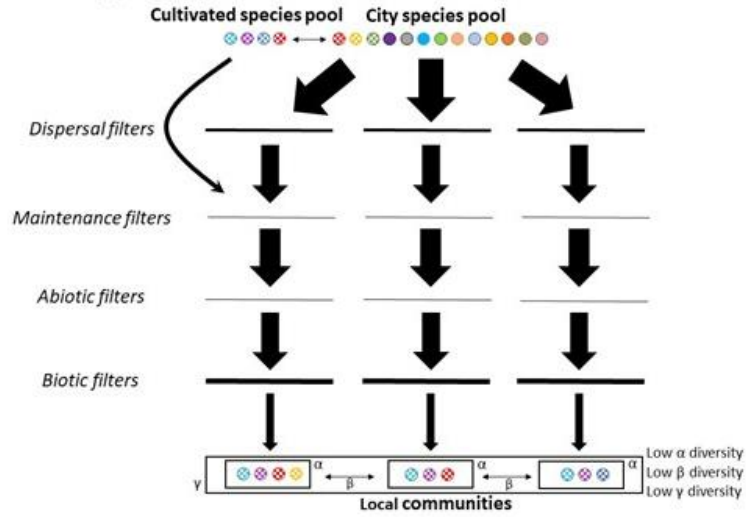
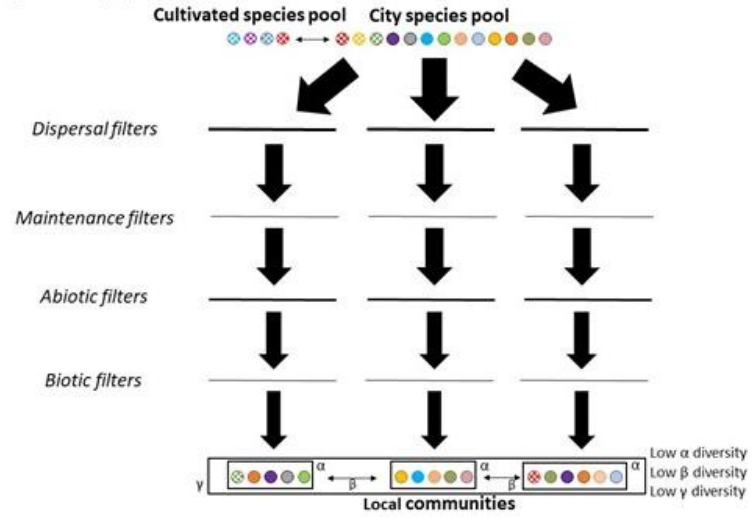


Fig. 3

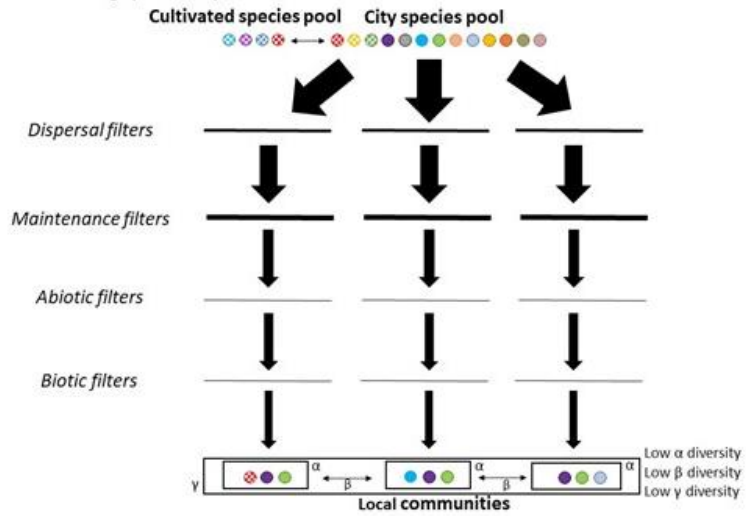
(A) Low assembly spontaneity



(B) High assembly spontaneity



(C) Low functioning spontaneity



(D) High functioning spontaneity

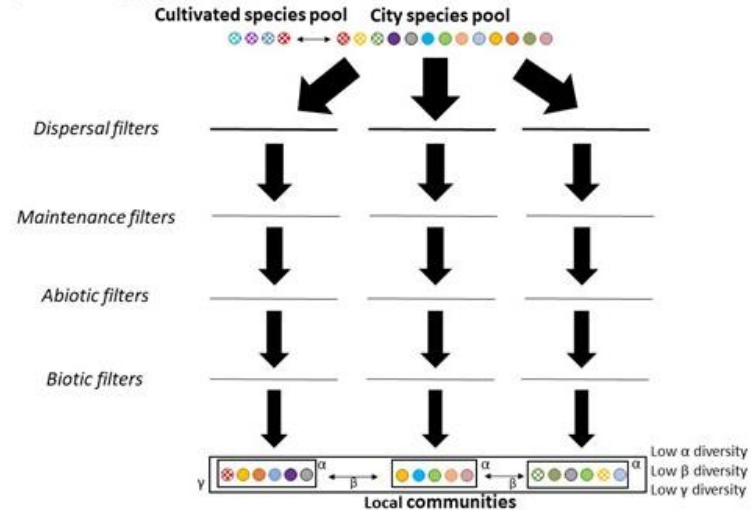




Fig. 4



Fig. 5



## Supplementary

**Fig. S1.** Experimentation of socio-ecological transformation, based on urban wilding and a participatory research by design approach. This study is taking place in green spaces of two collective residential areas in a medium-sized French city (Blois; a long-term study site of the LTSER Zone Atelier Loire, CNRS). Illustrations of study sites. Currently the green spaces contain trees, few shrubs and the grassy areas are mowed approximately every 15 days.

### Croix Chevalier



### Hautes Saules



**Fig. S2.** Longitudinal method used in the experimentation of socio-ecological transformation at the two sites shown in Fig. S1.

