Are really Nature-Based Solutions sustainable solutions to design future cities in a context of global change?

Chloé Duffaut, Pierre-Antoine Versini, Nathalie Frascaria-Lacoste

Are really Nature-Based Solutions sustainable solutions to design future cities in a context of global change? Discussion about the vulnerability of these new solutions and their probable unsustainable implementation.

Chloé Duffaut [a,1], Pierre-Antoine Versini [a,*], Nathalie Frascaria-Lacoste [b]

[a] Hydrology Meteorology and Complexity Laboratory, École des Ponts ParisTech, Champs-sur-Marne 77455, France

[b] Université Paris-Saclay, CNRS, AgroParisTech, Ecologie Systématique Evolution, 91190 Gif-sur-Yvette, France

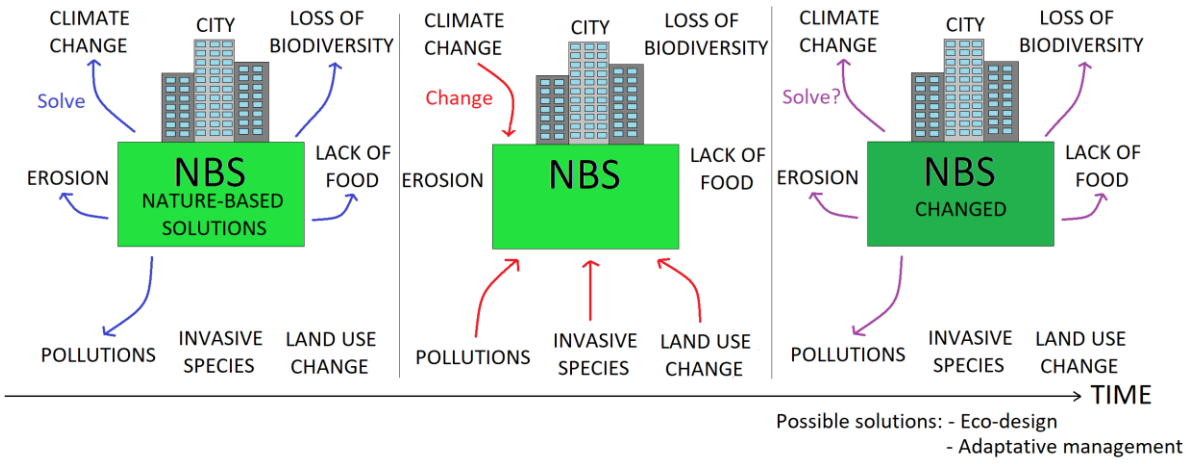
[1] Chloé Duffaut Left the Hydrology Meteorology and Complexity Laboratory, École des Ponts ParisTech, on 1st September 2021.

[*] Corresponding author: pierre-antoine.versini@enpc.fr

Highlights

- Nature-Based Solutions (NBS) in cities solve problems like floods, heat, etc.
- But NBS can be threatened by disturbances like global change, pollution, etc.
- In fact, these disturbances could notably alter services provide by NBS.
- To avoid this, NBS should be designed by considering socio-eco-evolution.
- It would also be good to diversify urban NBS, so that some survive disturbances.

Graphical abstract



Abstract

The urban ecosystem is a very challenging environment that faces many problems such as various pollutions, higher temperatures than its surroundings or flooding risks due to soil sealing. Nature-based solutions (NBS) seem to be good option to address these problems, while simultaneously offering benefits for facing climate change and the biodiversity crisis. Despite their potential, NBS can be threatened by various urban disturbance, namely: land use change, pollution, or invasive species. These disturbances can have multiple consequences on urban NBS, such as causing changes in plant characteristics/traits, altering the services they provide, and even make certain plant populations disappear, etc. In turn, these consequences may even jeopardize the solutions themselves, which then may no longer solve the problems they originally targeted. To avoid this, NBS should be eco-designed, i.e. designed in function of their environment. Their management should be adaptive and should also take into consideration the evolution of climatic and anthropogenic factors. The choice of species should not be left to chance or random: In this sense, is it better to plant native species for biodiversity conservation or exotic species that are more likely to resist global changes? Is it better to find resistant or ruderal species that have proven themselves in the face of certain disturbances? In any case, it would be good to diversify any NBS to have a better chance of survival in the face of global changes.

Keywords: Urban, biodiversity, ecosystem service, disturbance, sustainability

1. Introduction

The urban environment is a highly complex environment with substantial pressures on biodiversity. The five major urban pressures on wildlife are the presence of buildings, underground infrastructure, communication systems, industries, and urban population (Trojan,

1981). Moreover, the occurrence of hydro-meteorological hazards adds another layer of disturbances. In this vein, cities could be particularly hot during summer, with temperatures up to 10°C higher than those of surrounding areas (Kim, 1992). This phenomenon, called urban heat island, is due to a large heat excess from the rapidly heating urban surfaces that often consist of buildings, asphalt, bare soil and short grasses (Grimm et al., 2008). According to IPCC climate experts, the severity of heat waves and their frequency will increase in cities due to global warming and ongoing urbanization (IPCC, 2021). Cities are also highly susceptible to flooding risks, as ground surfaces in cities are often impervious, hence with low water infiltration rates in contrast to higher runoff values (Kalantari and Sörensen, 2019). Despite its characteristics, the urban environment is characterized with a particular biodiversity (Kowarik, 2011). For example, a study in Germany showed that some plants in heavily urbanized environments are being increasingly dispersed by humans and animals, and have become more nitrogen and heat tolerant (Knapp et al., 2010).

Nature-Based Solutions (NBS) are the most recent entry to the panel of expected solutions for cities. NBS is a new concept used in research and practice (Nesshöver et al., 2017). There are many definitions of this concept, but the best known are those of the International Union for Conservation of Nature (IUCN) and the European Commission (EC). The IUCN defines NBS as: *"actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits"* (IUCN, 2020a). The EC gives another definition that has been updated in 2020: *"Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions."* (European Commission, 2020a). This concept can be connected

to other concepts such as Ecological Engineering, Catchment Systems Engineering, Green and Blue Infrastructure, Ecosystem Approach, Ecosystem-based Adaptation/Mitigation, Ecosystem Services Approach/Framework, or Natural Capital. (Nesshöver et al., 2017). Urban NBS are also likely to provide answers to the circularity challenges of a city (i.e. circular resource management), especially with regard to the water cycle and the treatment, recovery and reuse of water and waste (Langergraber et al., 2021 a).

The purpose of this opinion article is to warn that urban NBS and the services they provide may be threatened by the various disturbances present in the city, and to provide suggestions for remedying them. Indeed, the sustainability of these NBS (used to make the city sustainable!) in the face of disturbances is not sufficiently taken into consideration. This paper therefore aims to and expose and discuss this possible paradox. As the disturbances and challenges of the urban realm will only be compounded with climate change, numerous questions arise: Faced with these numerous drivers of change, is the sustainability/durability of these NBS assured? Is there a risk of failure or of reduced performances in the face of the problem they are supposed to address? Should nature be left to its own means, even if the ecological trajectories will inevitably be disrupted, or should it be assisted to facilitate its adaptation? This article aims to address these questions and attempts to provide some recommendations for a sustainable implementation of urban NBS.

2. Methodology

This article is based on bibliographic work and logical reasoning. The first part will discuss nature-based solutions and ecosystem services in cities.

To account for forms of urban NBS in the scientific literature, a text-mining analysis was conducted to study the current NBS in urban environments. Carried out using the SCOPUS

database for peer-reviewed literature, the occurrence of some keywords used in publications on urban NBS from the appearance of the concept in 2016 until December 13, 2021 was studied. The keywords used for this search were: *nature-based* AND *solution* AND *city*. The analysis was then carried out for the titles, abstracts and keywords of the studied corpus (453 documents). Only the keywords appearing at least 8 times were conserved.

This first part will also present a particular study devoted to green roofs. Green roofs and their plants were chosen because the scientific literature on this type of NBS is extensive and exhaustive inventories of their plants exist. An individual analysis of several papers dedicated to green roofs was carried out (Köhler, 2006; Lundholm et al., 2010; Rochefort et al., 2016; Catalano et al., 2017; Riviere, 2019). These documents were retained because they provided an exhaustive list of used/studied species with their relative quantities. After analysing the different kind of species implemented on the roofs, the most commonly represented species have been identified. As a result, a list of 27 dominant (planted and spontaneous) plant species used on green roofs in temperate environments (Germany, Belgium, Canada and Switzerland) was obtained. Six plant functional traits (lifespan, pollination, root system, persistence of leaves, leaf surface per plant, stomatal conductance per leaf area) which seem essential for ecological functions (water retention, evapotranspiration, gas exchange, particle trapping, pollen transfer) and ecosystem services (regulation of hydrological cycles, flood risks and climate regulation, air and water quality regulation, pollination and support of biodiversity) were selected for our study. Then, the TRY plant traits database (https://www.try-db.org; Kattge et al., 2020) was used to quantify and qualify the 6 functional traits of the 27 dominant selected plants. Thanks to the richness of the TRY database, almost all the traits could be quantified/qualified for these 27 inventoried species. Based on these results, a composite portrait of a typical plant has been created (by averaging the numerical variables, and retaining the most common value for the qualitative variables; Table 1). As this analysis was

carried out on a relatively limited sample, it would be interesting to do further research on a larger sample of rooftops or even with other types of NBS present in the city.

The second part will deal with disruptions in the urban environment and their consequences on NBS and their associated plants. Finally, the last part will focus on the ways to overcome these disruptions and their consequences by proposing some possible solutions. The rationale behind this approach is to provide a detailed representation of NBS challenges and potential solutions to ensure the continuity of these solutions in the cities of tomorrow. The work done for this paper is illustrated in Figure 1.

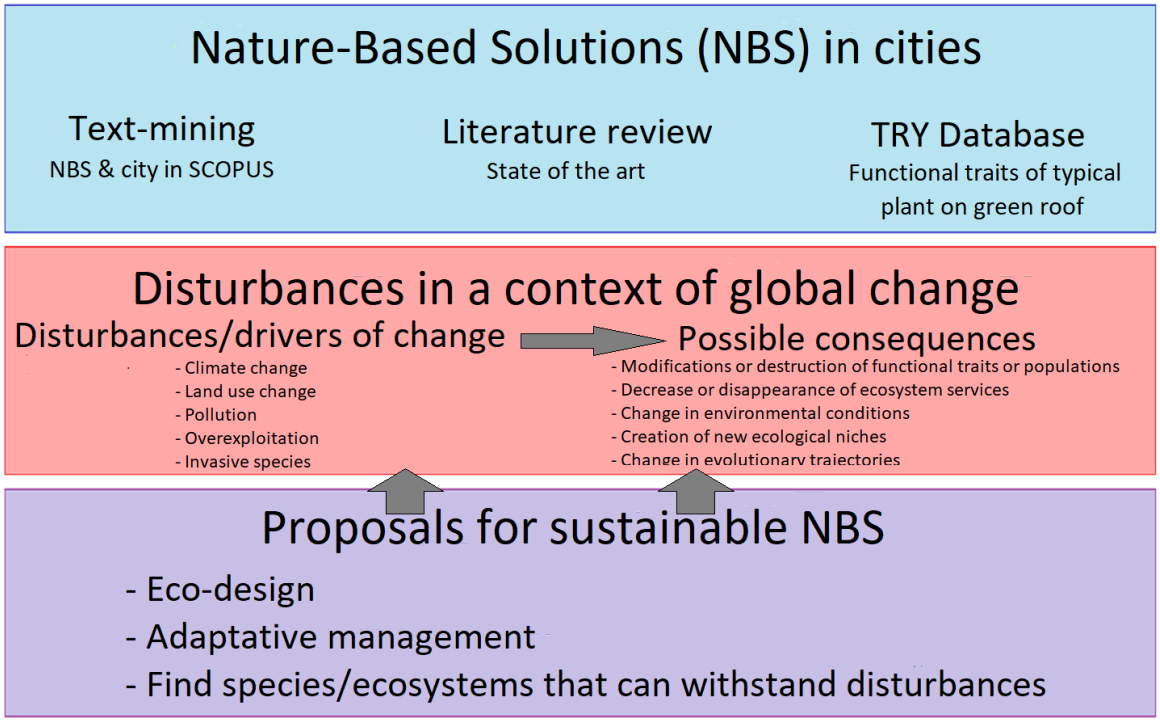


Figure 1: Illustration of the methodology and content of the article.

3. Nature-based solutions in the city

3.1 Nature-based solutions and ecosystem services in cities

Here, we focus on NBS in the urban environment. In this environment, NBS can take various forms (Dorst et al., 2019) such as urban forests (Tomao et al., 2017; Yao et al., 2017), green roofs and facades (Xing et al., 2017; Frantzeskaki, 2019), parks and street trees (Giannakis et al., 2016; Santiago Fink, 2016), ecological corridors (Giannakis et al., 2016), ponds, natural water retention areas or vegetated swales (Scott et al., 2016; Xing et al., 2017), pervious pavements (Fini et al., 2017), urban gardens (Cabral et al., 2017; Van der Jagt et al., 2017) including rain gardens (Scott et al., 2016), or urban agriculture (Artmann and Sartison, 2018). These forms of NBS are often aimed at flood prevention, urban heat islands mitigation, biodiversity conservation, recreation, food production, erosion prevention, or pollution reduction (Frantzeskaki, 2019; Hobbie and Grimm, 2020). Today, NBS are being used as tool for local adaptation and for short-term results, as part of pragmatic responses to manage emergencies. They are a direct answer to climate change and landscape fragmentation as they restore the vegetated area in the city. The benefits they provide, such as flood prevention, microclimate regulation or air quality regulation, are called ecosystem services. Ecosystem services are usually classified into four categories: supporting (providing habitats for species, and maintaining genetic diversity), provisioning (provision of food, freshwater and raw material), regulating (air quality regulation, microclimate regulation, noise reduction, and water drainage/purification) and cultural services (physical-mental health, moral well-being, ecotourism and recreation). These services are of particular interest in urban environments (Bolund and Hunhammar, 1999; Maas et al., 2006; Tzoulas et al., 2007), because the majority of human beings live in cities (La Banque Mondiale i.e. World Bank, 2020). By their multifunctionality and potential use to address multiple ecosystem services simultaneously, NBS are recognized as efficient tools to improve ecosystem services in urban areas (Raymond

et al., 2017; Castellar et al., 2021). For this reason, several policy initiatives promoting NBS measures in cities have recently raised (European Commission, 2020b; IUCN, 2020b). Therefor NBS and their associated ecosystem services play vital roles in addressing urban challenges and in enabling planning towards sustainable and resilient cities (Andersson et al., 2014; Almenar et al., 2021). Ecosystem services (an anthropocentric concept) can be seen as the result of ecological functions (a concept centred on ecosystems and their components) provided by living beings and/or abiotic components/conditions. In this article, only biotic components (living beings) especially plants are considered. A definition of ecological function is the interaction of species or through their ecological role where a species or group of species maintain a biogeochemical flux or pool, and/or support ecosystem productivity (Brodie et al., 2018). In turn, these functions are influenced by individual characteristics often referred to as functional traits. For instance, in the case of a plant these would be its leaf shape or persistence, type of pollination or dispersal means (Knapp et al., 2010). As such, the air quality regulation as an ecosystem service is linked to the ecological function of particle trapping, which in turn depends on the functional trait of the leaf surface [larger leaf area gives a greater particle capture potential] (Commissariat Général au Développement Durable, 2010; Chen et al., 2015).

3.2 Finding: How are NBS present in cities today?

The integration of NBS in cities raises many questions on the species that are usually used, the way they are managed and on the practices that are used for their maintenance. As already described, NBS in the city can take many forms. Consequently, practices vary accordingly: human interventions on a site can range from very limited modifications to major ones, such as the creation of ecosystems (Gómez Martín et al., 2020). NBS requiring greater

management efforts are usually implemented in the downtown areas of cities, while in the peripheries, NBS that require less management are often present (Krauze and Wagner, 2019).

The analysis of urban NBS forms in the literature showed that the most publishing journals on this topic were found to be: Sustainability (MDPI), Urban Forestry and Urban Greening (Elsevier), Environmental Research (Elsevier), Science of The Total Environment (Elsevier) and Water (MDPI). Accordingly, the main types of NBS described in literature were found to be: green spaces (82), urban forests (81), trees (25), green roofs (22), urban agriculture (19), recreational parks (18) and wetlands (8).

The typical plant of green roofs made from the list of 27 dominant species is an important result, but it is not a panacea. The plant species are rather small and lack heterogeneity. Pollination of this typical plant is dependent on insects, especially bees, which makes it more vulnerable to disturbance that can be drivers of pollinator loss (Potts et al., 2010). The modelled plant has a rather long leaf persistence time and average leaf surface and stomatal conductance. These trait values allow an important performance of water retention, evapotranspiration, gas exchange and particle trapping (among other ecological functions) that are related to the services of the hydrological cycle and water flow regulation, (micro)climate regulation, water and air quality regulation. However, these functions and services can be influenced by the many disturbances that characterize the urban environment.

4. Nature-based solutions necessarily disrupted?

4.1 Many disruptions, especially in the city

Often ecosystems, especially urban ones, are hyper-disturbed. Even when ecosystems are left to self-organize, there are always drivers of change such as climate change, land-use change,

pollution, overexploitation and invasive alien species (Pereira et al., 2012). In the urban environment, disturbances are even more numerous than in the surroundings, given the strong anthropogenic influence. Indeed, the world's urban population is steadily increasing; 34% of humans lived in cities in 1960 and have increased to 56% in 2020 (La Banque Mondiale i.e. World Bank, 2020). Horticultural plants, which are very present in cities, are often the source of invasive plant spreading (Reichard and White, 2001). Human-induced drivers of change can then affect evolutionary trajectories (Palumbi, 2001). For example, heavy metal exposures have caused changes in the evolutionary properties of (resistance) plants living in contaminated sites (Wu and Kruckeberg, 1985). Another example is that in habitats disturbed by humans, plants have a lower level of outcrossing than in an undisturbed environment (Eckert et al., 2010) which could be due to reduction of outcrossed pollen receipt (Eckert et al., 2010). Indeed, even if humans do not directly act on an ecosystem, they still have an indirect impact via climate change or various pollution sources.

However, disruptions are not always sudden. Some of them can occur continuously like climate change. As already mentioned, the IPCC reports that *"Cities intensify human-induced warming locally, and further urbanization together with more frequent hot extremes will increase the severity of heatwaves"* and *"Urbanization also increases mean and heavy precipitation over and/or downwind of cities"* (IPCC, 2021). The increase of extreme events (drought, rainfall) in terms of intensity and frequency can clearly have consequences on vegetation (Zhang et al., 2021). Therefore, the selection of plants species that can survive water-deficits, especially on dry soil as green roof substrates is crucial (see Du et al., 2019). The consequences of climate change can also be temporary positive as global warming can advance the phenological phases of leaf development and delay the phenological phases of leaf senescence (Wohlfahrt et al, 2019).

4.2 Possible consequences of disturbances on NBS

The multitude of disturbances present in the city (climate change, land-use change, pollution, overexploitation and invasive alien species) can have multiple consequences on urban NBS, ranging from simple modifications of functional traits and/or populations of living beings to their destruction. Indeed, disturbances also called drivers of change can modify the functional traits of plants, create new ones or eliminate them. Some of these traits named “keystones” are very important for humans, as they interfere with many ecosystem services (Hevia et al., 2017). The modification or disappearance of such traits can therefore mean the decrease or the disappearance of many of their related services. The leaf surface of a plant is one of these "keystones" traits, as it is linked to many services such as the regulation of hydrological cycles, flood risk, microclimate and air quality. This trait appears to be most affected by land use change (Hevia et al., 2017).

The above-mentioned drivers of change (climate change, land-use change, pollution, overexploitation and invasive alien species) can lead to the selection of plants that have certain functional traits. For example, urbanization can lead to the selection plants that are more tolerant to nitrogen and heat (Knapp et al., 2010). Human disturbances can also destroy parts of plant population or even the whole, even the specimen present on a site, thus reducing site-biodiversity. Indeed, a study on a Chinese island showed that the direct factors making small plant populations susceptible to extinction were human disturbances (Chen et al., 2014). According to Köhler (2006), floristic diversity of green roofs is mainly influenced by weather conditions (temperature and rainfall), so climate change can have a serious impact on this diversity in the future. The change of land use in the environment of a given NBS can alter the necessary conditions necessary for solutions’ life cycle or for the delivery of its purposes, according to the complementary land use concept of Colding (2007). This concept is built *“on the idea that land uses in urban green areas could synergistically interact to support*

biodiversity when clustered together in different combinations" (Colding, 2007). For example, private gardens adjacent to urban public parks would enhance bird diversity through the landscape complementation functions provided by native tree cover, berry bushes, ponds, or freshwater springs, which increase the likelihood of attracting species (Blair, 1996; Melles et al., 2003).

Destruction of populations and/or changes in environmental conditions can lead to the creation of new ecological niches, and thus the colonization of a NBS by new species. It can also change the dominant species that are most likely to provide ecosystem services. Indeed, according to Xie et al. (2018), the functional characteristics of dominant plant species on green roofs are important to provide several services. Drivers of change can therefore destroy natural equilibrium and can also change evolutionary trajectories through adaptation. Accordingly, the question of impoverishing the evolutionary trajectories of the species present can be raised. It would also be important to refocus human/non-human relationships on maintaining evolutionary potential (Lecomte and Sarrazin, 2016). Therefore, the risk of reducing or losing ecological functions and ecosystem services of urban NBS through human disturbances exists. This phenomenon has already been observed in non-urban environments, land use intensification was linked to the loss of functional traits (such as thin bark and large size for trees in Brown et al., 2013) and the reduction of several ecosystem services (such as the harvest of fuel wood and construction timber in Brown et al., 2013; Laliberté et al., 2010; García-Llorente et al., 2015). In urban environments, this raises the question of whether the targeted ecosystem services are still being provided, and whether the original problems are still being solved despite the anthropogenic disturbances present in the city and their consequences. Accordingly, one can also question if we are still dealing with nature-based solutions at this level.

5. How to deal with these disturbances and their consequences?

5.1 Eco-design and adaptive management to overcome disruptions in the city

The previous section raised the question of how to deal with these disruptions and their consequences for NBS in the city. It can also relate to the question of ensuring the sustainability of the sought solutions. Therefore, it could be interesting to have ecosystems that are well-maintained over time and which are autonomous with planted and spontaneous species that reappear from one year to another or reproduce on site. Eventually, new colonisations that replace plants that have disappeared from the ecosystem can appear. However, the question of how to achieve this sustainability is raised. The idea is to work on the long term, to tap the full potential of the species' life cycles, and to anticipate the drivers of change and their consequences. For this purpose, urban NBS could be eco-designed, hence accommodating for life cycles and natural adaptation. Eco-design is based on the fact that: *"the environment helps to define the direction of design decisions and the environment becomes a co-pilot in product [here the NBS] development"* (Brezet, 1997). The design process also requires collaboration between different sectors in order to use the full potential of NBS to address multiple urban challenges simultaneously (Langergraber et al., 2021 b). There is also the question of NBS-derived ecosystem service sustainability. But, is there a will to maintain all of these services as much as possible on the long term? Or target one or more in particular? The purpose is to move towards a dynamic ecological balance that provides ecosystem services, hence maintaining the durability of the designed/implemented NBS.

Regarding the management of NBS in cities for coping with disruptions, a legitimate question arises: do we let "nature" take over or do we accompany it? It would be probably a good idea to let nature take over more often in urban NBS, without direct human intervention or just the bare minimum, such as an annual maintenance of green roofs, the removal of invasive plants,

306 etc. This type of *let it happen* management encourages the development of spontaneous
307 species that are important for the functioning of ecosystems (Couvet and Ducarme, 2018) and
308 allows ecosystems to become somewhat self-organized. Ecosystems are thus closer to a
309 functional natural state. It also reduces the financial, labour and time costs associated with
310 NBS maintenance. Nesshöver et al (2017) stress the fact that NBS governance must be
311 adaptive. Indeed, management must respond to the "reality of the field" and react to
312 unexpected events. Lambert and Donihue (2020) go further to stress that evolving urban
313 biodiversity requires incorporating evolutionary perspectives into management for these
314 efforts to succeed given the dynamic nature of the urban environment. It is also important to
315 take into consideration the landscape's heterogeneity, the ecological dynamics and the
316 evolutionary consequences on biodiversity, i.e. to have an evo-centric approach (Lecomte and
317 Sarrazin, 2016). Thus, solid progress towards socio-eco-evolution in the city is needed (Des
318 Roches et al., 2021). Accordingly, human societies, non-human living beings and their
319 ecology and evolution, as well as their interactions should be better accounted for. Whether in
320 eco-design or management, it could be interesting to mimic nature and its ecosystems in an
321 effort to understand their behaviour in the face of various disturbances.

322

323 5.2 Finding species and ecosystems that can withstand urban disturbances

324 One of the objectives of NBS is to provide environmental benefits (see IUCN and European
325 Commission definitions). In this context, one of the main goals is the conservation of
326 biodiversity. For this purpose, it may be a good idea to use local plant species, with species
327 already present in the city where the NBS is implemented. As a result, vegetation populations
328 will be larger and therefore more viable. This is important as small and range-restricted
329 populations are highly vulnerable to extinction (Terborgh and Winter, 1980; Gilpin, 1986).
330 The establishment of NBS in the city can also be an opportunity to introduce species that were

not initially present in the urban environment, but in its surroundings, hence increasing biodiversity in the city. There are already initiatives that promote and facilitate the use of local wild species such as the French label "Végétal local" (Végétal local; https://www.vegetal-local.fr/). However, will these local species be able to cope with disturbances like global warming? Perhaps it would be better to plant exotic (non-invasive) species that can withstand droughts for example or rising temperatures? In support of this argument, one study showed that in North America, the phenology of exotic species adapted better to climate change than native species (Wolkovich et al., 2013).

Another solution is to find and install plant species that can cope with the disturbances present in the city, such as "resistant" or ruderal species, or species that have been proven to work in a given context in the face of a given disturbance. The rationale behind this approach is the concepts of ecological resilience, which is the ability of a living system to recover the structures and functions of its baseline state after a disturbance (Holling, 1973), and resistance, which is the ability of a system to remain fundamentally unchanged when subjected to a disturbance (Grimm and Wissel, 1997). The idea is to return to the initial trajectories, before disturbances (or new favourable ones). However, this aspirational target is not always guaranteed. In the case of new evolutionary trajectories, one can speak about transformability, which is the ability to create a fundamentally new system when ecological, economic, or social structures make the existing system unsustainable (Walker et al., 2004). In this sense, anticipating changes in eco-evolutionary trajectories by experimenting or studying correlations in urban environments could be an interesting platform to explore.

355 5.3 Issues of scale and risk of failure

356 It could also be necessary to think about the challenges of urban spatial scales (e.g. building,
357 allotment, district, city, agglomeration, or megalopolis). Hutchins et al. (2021) have already
358 addressed this issue for optimizing NBS for resilient cities. According to the Authors, this
359 requires the development of a tools that take into consideration the optimization of ecosystem
360 services and environmental quality indicators. It may also be interesting to study the
361 connectivity of existing and future NBS. Indeed, the resulting ecosystem services do not only
362 depend on the scale of implementation, but also on the network linking them at a larger scale.
363 To provide ecosystem services at large scales, NBS have to be widely implemented. As
364 demonstrated by Versini et al. (2020) for green roofs in European conurbations, fractal
365 analysis can used as an innovative multi-scalar tool to provide information on the
366 heterogeneity of green roofs spatial distribution and to optimize their deployment scenarios
367 depending on the targeted impact(s).

368 There is a need for collective awareness on the risks of failure of any NBS. This includes the
369 fact that the *let it happen* is very likely to be disrupted by factors such as climate change.
370 Additional failure risks can also result from the current implementations of urban NBS that
371 may have disappointing results (such as disservices related to safety, aesthetics or health for
372 instance, see Gómez-Baggethun and Barton, 2013). Therefore, it could be useful to go to
373 diversify choices, and "not to place all eggs in the same basket". In an unknown future, the
374 more potential solutions emerge, the more likely some of them will resist disruptions. The
375 distribution and the diversity of these solutions will echo to the land use concept developed by
376 Colding (2007).

377

378

6. Conclusion

Urban environments are very complex and challenging ecosystems. Drivers of change influencing this particular context are numerous. On one hand, the increase of urban populations and the resulting intensifications of urban cover can modify the water cycle (by inducing imperviousness and heat storage), facilitate invasive species spreads and create various types of pollution. On the other, climate change can intensify the occurrence of extreme events like flooding or heat waves.

The use of NBS is therefore one of the main means to help cities adapt to these constraints and to make them more resilient. For this reason, NBS for climate change adaptation are starting to gain prominence in scientific discourses.

Through the (re)introduction of nature, NBS also represent a good solution for biodiversity and for its effective return to the city. However, if the constraints of global changes on societies are now obvious and well documented, the same is probably also true for the non-human living world. Nevertheless, the latter's response to these constraints remains uncertain. To our knowledge, scientific literature has rarely addressed this question. Thus, the use of NBS for mitigation or adaptation purposes in cities has to be examined with great caution. NBS are usually implemented to mitigate or to adapt the environment to the current situation, often leaving aside the need to forecast the evolution of future constraints and how NBS will respond to them. This stationary point of view has obviously some limitations.

Indeed, resistance to strong constraints also has its limits for city biodiversity. Accordingly, it is difficult to predict whether introduced or local species will survive extreme conditions which they may face. It is also unclear whether this newly introduced nature will be able to

provide the ecosystem services for which it was initially planned for. Climatic hazards, such as various types of pollution, can indeed alter some of these "keystones" traits.

This clearly questions the way of approaching the introduction of biodiversity in cities. The time has come to question whether Nature-Based Solutions should be considered as a way to rethink our cities in their entirety. A paradigm shift is surely necessary to move from business-as-usual approach “adapting to what?” all the time, to rather “adapting what to what?”, taking into account the possibilities of the territory and its limits.

This approach requires the adoption of a systemic and dynamic approach that gives the diversity, complementarity and renewal of species an important role to ensure services, their sustainability and their adaptability. A stronger involvement of ecologists is required to question these points at scales that go beyond that of the infrastructure on which NBS are often installed. It is about understanding better understanding how a particular NBS fits its surrounding environment, and how its complementarity with the whole system can benefit everyone.

In addition, a more global reflection integrating local authorities, engineering design offices and urban planners could be beneficial. The objective is to link aspects of biodiversity with planning, public policies, and climate, in order to share the knowledge with more technical and decision-making organizations. This framework should allow a more successful and cautious reintroduction of nature into cities hence avoiding “greenwashing”

Acknowledgments:

This work has been supported by the ANR EVNATURB project (ANR-17-CE22- 0002-01) dealing with the evaluation of ecosystem performance for renaturing urban environments. The authors are very grateful for the fruitful comments and suggestions given by Mario Al Sayah from École des Ponts ParisTech. They also thank the TRY initiative.

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