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Short communication

## Nature-based solutions for resilient landscapes and cities

 Raffaele Lafortezza<sup>a,b,\*</sup>, Jiquan Chen<sup>b</sup>, Cecil Konijnendijk van den Bosch<sup>c</sup>, Thomas B. Randrup<sup>d</sup>
<sup>a</sup> Department of Agricultural and Environmental Sciences, University of Bari A. Moro, Via Amendola 165/A, 70126 Bari, Italy

<sup>b</sup> Center for Global Change and Earth Observations (CGCEO)/Geography, Michigan State University, 1405 S. Harrison Road, Manly Miles Building, East Lansing, MI 48823, USA

<sup>c</sup> Department of Forest Resources Management, University of British Columbia, 2424 Main Mall, Vancouver, British Columbia, V6T 1Z4, Canada

<sup>d</sup> Department of Landscape Architecture, Planning and Management, Swedish University of Agricultural Sciences, 23 053 Alnarp, Sweden

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## ABSTRACT

Nature-based solutions (NBS) are increasingly applied to guide the design of resilient landscapes and cities to enable them to reach economic development goals with beneficial outcomes for the environment and society. The NBS concept is closely related to other concepts including sustainability, resilience, ecosystem services, coupled human and environment, and green (blue) infrastructure; however, NBS represent a more efficient and cost-effective approach to development than traditional approaches. The European Commission is actively engaged in investing in NBS as a driver in developing ecosystem services-based approaches throughout Europe and the world. The pool of knowledge and expertise presented in this Special Issue of Environmental Research highlights the applications of NBS as 'living' and adaptable tools to boost the capacity of landscapes and cities to face today's critical environmental, economic and societal challenges. Based on the literature and papers of this Special Issue, we propose five specific challenges for the future of NBS.

### 1. Introduction

Governments and organizations worldwide, with the help of academia, are turning to nature to mitigate the pressing environmental, economic and societal challenges caused by the industrialization era. They have understood the necessity of passing from building 'gray' to building 'green' infrastructure to restore ecological balance within the urban landscape for the dual purpose of developing resilient ecosystems and healthier societies. This thinking is based on the fundamental role that nature plays through the provision of ecosystem services in supporting the economy as well as the livelihood of citizens (e.g., Cohen-Shacham et al., 2016; Lafortezza and Chen, 2016; Maes et al., 2016; Kabisch et al., 2017a; Raymond et al., 2017). In this regard, the advantages of applying an ecosystem services-based approach using green infrastructure have been widely described in the scientific literature. For example, Elmqvist et al. (2015) state that the benefits of investing in restoring green (and blue) infrastructure in urban areas may not only be ecologically and socially desirable but also economically advantageous. In its Green Infrastructure Strategy report, the European Commission (EC) states that green infrastructure helps to avoid reliance on infrastructure that is costly to build when nature can provide less expensive and long-lasting solutions, as well as deliver health-related and ecological benefits (EC, 2013).

Acknowledging the important role that green infrastructure and ecosystem services provide for the environment and society, the EC's Directorate-General (DG) Research and Innovation recently launched the concept of 'nature-based solutions' (NBS) as a way of making natural ecosystems an integral part of sustainable development (EC, 2015). Indeed, the strength of the NBS concept lies in its integrated perspective in addressing societal challenges. The DG Research and Innovation commissioned an interdisciplinary Expert Group on 'Nature-Based Solutions and Re-Naturing Cities' to define and operationalize the concept and to identify research needs and priorities (EC, 2015). The Expert Group delivered its report in 2015 and defined NBS as "living solutions inspired by, continuously supported by and using nature, which are designed to address various societal challenges in a resource-efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits" (see also Faivre et al., 2017 in this Special Issue).

NBS has largely evolved from previous concepts and/or principles (e.g., sustainability, resilience, ecosystem management, ecosystem services, coupled human and environment, and green (and blue) infrastructure) (Forest Ecosystem Management Assessment Team FEMAT, 1993; Millennium Ecosystem Assessment MEA, 2005; Chen and Liu, 2014; EC, 2015; Cohen-Shacham et al., 2016; Potschin et al., 2016; Davies and Lafortezza, 2017), but with a central focus on the multiple

\* Corresponding author at: Department of Agricultural and Environmental Sciences, Università degli Studi di Bari A. Moro, Via Amendola 165/A, 70126 Bari, Italy.  
 E-mail address: [raffaele.lafortezza@uniba.it](mailto:raffaele.lafortezza@uniba.it) (R. Lafortezza).

co-benefits for the environment, economy and society in urban (and to some degree rural) landscapes. The fundamental belief is that NBS can represent more efficient and cost-effective solutions than traditional approaches to development. NBS can be linked to the sustainable use of nature and ecosystems protection, to the sustainability and multifunctionality of ecosystems, and to the design and management of new ecosystems (EC, 2015). Innovative uses of existing ecosystems should also be considered (e.g., the role of urban woodland and street trees in climate change adaptation and the role of urban parks in building social cohesion). In light of the above, growing attention is being given to NBS as a tool whereby ecosystems and the services they provide are directed at addressing the increasing challenges (e.g., climate change, food security, or economic competitiveness to develop more sustainable and resilient cities) societies face (Maes and Jacobs, 2015).

The NBS approach focuses on the benefits to individuals and their environment, allowing for sustainable solutions that can respond to environmental change and hazards in the long-term. Thus, NBS can help us remain within a safe operating space for humanity, improve local ecological and social sustainability, and guarantee long-term productivity. Countries worldwide have the opportunity and responsibility to apply NBS as a guiding economic strategy toward modifying their use of natural resources for the benefit of nature and society (Maes and Jacobs, 2015). Despite its different scope and ambitions, the NBS approach should not be considered in isolation, given that it has evolved from the ‘green infrastructure’ concept (Davies et al., 2006; Laforteza et al., 2017; Pauleit et al., 2017). NBS is also contingent on other concepts, such as ecosystem-based adaptation, urban green infrastructure and ecosystem services, inasmuch as these three are subsets of NBS leading to maximize its benefits and integration (Pauleit et al., 2017). Hence, NBS functions as an umbrella to the other concepts, but with a particular focus on the deployment of actions inspired by nature (e.g., urban forests) on the ground compared to high-tech solutions.

## 2. NBS applications across scales

Having recognized NBS as one of the most comprehensive approaches for developing resilient landscapes and cities, governments and scientific communities are currently faced with the challenge of moving from general pronouncements to practical applications. The EC (2015) has proposed a suite of actions for re-naturing cities through the implementation of NBS. These include: (i) identifying obstacles (e.g., regulatory) and enabling factors (e.g., leverage of funding) to the delivery of NBS; (ii) raising citizens’ awareness, engagement and empowerment; (iii) integrating research, policy and the economic sector to provide the evidence base for NBS; (iv) scaling up NBS across Europe through a more comprehensive evidence base; (v) developing new business and investment models as well as legal and institutional frameworks for NBS; and (vi) developing and deploying NBS that maximize cost-effectiveness and co-benefits. In addition, four principal goals that can be addressed by NBS have been identified:

1. Enhance sustainable urbanization through NBS to stimulate economic growth as well as improve the environment, making cities more attractive and enhancing human wellbeing;
2. Restore degraded ecosystems using NBS to increase their resilience, enabling them to deliver vital services and withstand other societal challenges;
3. Develop climate change adaptation and mitigation strategies using NBS to provide more resilient responses and enhance carbon storage; and
4. Improve environmental risk management and resilience using NBS to produce greater benefits than conventional methods and offer synergies in reducing multiple risks.

Based on these four goals, seven main NBS actions are recommended to be taken forward: (1) urban regeneration through NBS;

(2) NBS for improving wellbeing in urban areas; (3) establishing NBS for coastal resilience; (4) multifunctional nature-based watershed management and ecosystem restoration; (5) NBS for increasing the sustainable use of matter and energy; (6) NBS for enhancing the insurance value of ecosystems; and (7) increasing carbon sequestration through NBS.

In the various reports and publications issued by the EC, a range of examples of NBS have been presented; these include, but are not limited to: urban agriculture for local food production and social cohesion; green roofs for climate adaptation; regeneration of abandoned industrial land by afforestation or park creation; rain gardens for storm-water regulation; green spaces for promoting human health; and the use of permeable surfaces and vegetation in urban settings.

The EC’s documents, coupled with the scientific literature, demonstrate how the main goals and re-naturing actions are considered in tandem for the advancement and application of the NBS approach. For example, the EKLIPSE Expert Working Group (Raymond et al., 2017) focuses on *Restoring degraded ecosystems* (goal) and *Establishing NBS for coastal resilience* (action) in their ‘NBS Impact Assessment Framework’, where the actions are viewed as challenges to be addressed. Although these sources consider all the goals and re-naturing actions in a broad sense, each one discusses a select number from a more targeted perspective. To showcase the suggested goals and actions of NBS, we have selected case studies from different regions around the globe. We explored a number of different sources, including official reports from international organizations and expert working groups as well as publications from scientific journals. Table 1 illustrates the results of this search, in chronological order. For each source we have identified the geographic location and/or scale of application (i.e., Global, Europe, etc.) and the main thematic goals and re-naturing actions dealt with, based on the EC’s classification (EC, 2015). In addition, we examined the main impacts of each NBS application and the key lessons that could be learned. For example, at the global scale, one of the most seminal works is the World Bank (2008) on biodiversity, climate change and NBS. This report focuses on three of four thematic goals and four of seven re-naturing actions. The impacts center on the need to support innovative ways for improving the management of natural habitats through Bank-funded energy and infrastructure projects as well as development policy lending (Table 1). The key lessons are drawn from single case studies and can be scaled up to foster new NBS strategies. More recently, the IUCN Report (Cohen-Shacham et al., 2016) approaches NBS through three thematic goals and four re-naturing actions to address societal challenges by unifying NBS interventions within a single operational framework. An important lesson to be learned from this source is that NBS could enable vulnerable societies to better adapt to water, food and energy shortages resulting from climate change. At European scale, besides the main reports from the EC (2013, 2015), additional information regarding NBS applications could be derived from two most recent publications: Nikolaidis et al. (2017), who focus on new approaches to improve regulatory instruments, share best commercial practices and demonstrate the long-term value of NBS, and Kabisch et al. (2017b), who provide a compendium of contributions looking at NBS for climate change adaptation in urban areas.

We also uncovered a report from the Asian Development Bank (2016) highlighting the capacity of NBS in building resilience in towns and cities in the Greater Mekong Subregion (Southeast Asia). Among the impacts foreseen by this study is the need to leverage partnerships for creating policy shifts, innovation in planning, design and implementation of NBS in the Mekong towns.

## 3. NBS at a glance

In a global context of mounting challenges (e.g., climate change) and human activities (e.g., rapid urbanization), this Special Issue of Environmental Research attempts to lay the theoretical and applicable foundations of the NBS concept by focusing on the most recent

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