



REGREEN
NATURE-BASED SOLUTIONS

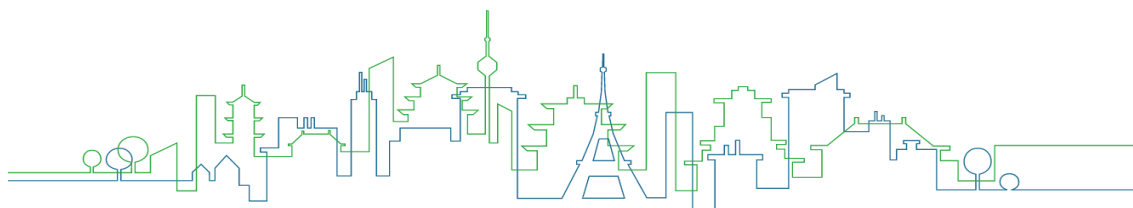
Fostering nature-based solutions for smart, green and
healthy urban transitions in Europe and china

Deliverable N°7.2.

WP N°7 Urban living labs

Training kit for training workshops

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DOCUMENT INFORMATION

GRANT AGREEMENT No.	821016
DOCUMENT TYPE ¹	R
WORKPACKAGE No. /TITLE	WP7 / Urban living labs
LEAD CONTRACTOR	Institut Paris Region
AUTHOR(S)	Marc Barra (IPR) Gwendoline Grandin (IPR)
REVIEWED BY	Åsa Sang Ode (SLU), Marianne Zandersen (AU)
PLANNED DELIVERY DATE	28.02.2023
ACTUAL DELIVERY DATE	31.03.2023
DISSEMINATION LEVEL ²	PU

¹ Type: P: Prototype; R: Report; D: Demonstrator; O: Other.

² Security Class: PU: Public; PP: Restricted to other programme participants (including the Commission); RE: Restricted to a group defined by the consortium (including the Commission); CO: Confidential, only for members of the consortium (including the Commission).

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EXECUTIVE SUMMARY

Enhancing nature-based solutions in cities requires major changes in vision and approaches to traditional cities management. Training stakeholders to novel ecological practices is thus a crucial step in the process of mainstreaming nature-based solutions.

This document describes why and how to organize training workshops on nature-based solutions for cities (agents, decision-makers and city stakeholder). It aims to provide ideas for nature-based solutions training and improve their deployment. All the ideas and resources shared in this training kit are intended to be adapted according to the needs and expectations of the participants.

Feedback from the participants at the Aarhus Urban Living Lab training workshop highlight the importance in such trainings to share a common language about nature-based solutions, to convince about their benefits, and to constitute a team to improve their implementation.

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1 INTRODUCTION

1.1 Why organize training about nature-based solutions?

Today, climate change is an undeniable reality, and the consequences are already being felt through heatwaves, droughts, or flooding. The evolution of the problem has become a major cause of concern to find solutions. But climate change is only one aspect of a wider mutation; we are also seeing unprecedented losses in biodiversity, and the two phenomena are inherently linked. Biodiversity is changing in reaction to the impacts of climate change, but it can also act as reservoir of potential solutions. Well-maintained ecosystems contribute to both the mitigation of climate change and help us adapt to its effects (flooding, landslide, run off, heat urban island...). This is what we called “nature-based solutions”: solutions that address both the ecological and climate crisis and generate multiple benefits. They may be applied in various contexts, in agricultural, forest, rural or urban areas.

In recent years, nature-based solutions have begun to emerge in cities and refer to a large range of actions from protecting, restoring, or even creating new ecosystems. Nature-based solutions have gained popularity as an integrated approach that can address climate change and biodiversity loss (Seddon et al, 2021), as well as taking into account the additional benefits for the people (including oxygen production, carbon storage and particle filtration, recreational attributes and the generally positive use of public spaces). However, nature-based solutions are a relatively recent notion, it remains open to different interpretations depending on the stakeholders involved, be they ecologists, developers, planners, or landscapers. In urban settings, nature is still often perceived as an approach to landscaping whose main aim is to create a green decor that makes the city more attractive. Many so-called NBS projects refer to urban “greenery” and focus on a few aspects (aesthetics, stormwater management) rather than an integrated approach based on science in ecology. More research is needed to clarify the links between biodiversity and NBS design. It thus seems vital to return to the source of nature-based solution and the different approaches it encompasses. Lastly, development of nature-based solution is at a crossroad of disciplines and fields of practices, including ecology, planning, green spaces management, living environment... It leads to transversal actions involving various municipal departments, stakeholders, and policy makers, who don’t have the same level of knowledge regarding NBS. Therefore, it is important to train local actors in nature-based solutions. This leads to cross-cutting actions involving various municipal departments, external partners, and decision-makers, who do not have the same level of knowledge. This is why nature-based solutions training workshops is so important.

Nature-based solutions

This term refers to initiatives aimed at the conservation, management, and restoration of ecosystems. Their aim is to attenuate climate change (e.g. via carbon capture and storage) and to facilitate adaptation to climate change (e.g. via protection against storms, flooding and landslides). These solutions can complement or replace the grey infrastructure traditionally used in regional development. The advantage of nature-based solutions is that they are multi-functional whereas grey solutions only solve one problem at a time. As well as benefiting climate and biodiversity, they have the advantage of helping to improve the living environment and health of city-dwellers at lower cost to local authorities. Nature-based solutions apply to all environments on all scales (farmland, woodland, aquatic and urban environments) and help enhance the resilience of local regions to global change.

1.2 Objectives of a NBS training workshop

Training workshops on nature-based solutions have multiple objectives. Firstly, to redefine the concept as it remains open to different interpretations. The aim is to enable participants to understand the complexities of nature-based solutions, identify how they can be applied in different settings and the various approaches it encompasses. It is important to remind that ecosystem services delivery is dependent on the way that nature-based solutions are designed and managed (biodiverse-design and management vs non-biodiverse). For instance, carbon sequestration, water regulation, will vary a lot according to the ecological quality of the NBS considered. And generally high level of biodiversity and maximization of ecological functions is a way to increase ES. Biodiversity and ecological traits are not just an *environmental challenge* but are part of NBS definition. At the end of the training, participants must share a common language.

Training workshops provide a valuable opportunity to share experiences and feedback, enabling a better understanding of how theoretical concepts can be applied in practical situations. They offer ideas for action and persuasive arguments to help convince. In addition, these workshops facilitate meetings between agents from different departments within a city, who do not usually work or interact with each other. Workshops also provide the opportunity to share an informal moment of exchange between agents, decision-makers, or external partners. They facilitate collaboration, networking. It is a way to build a transdisciplinary team for working on nature-based solutions and bringing meaningful change.

Main objectives of the training workshop

- Providing scientific background in urban ecology and understanding the benefits of Nature-based solutions
- Linking NBS design and management with ecosystem functioning and biodiversity
- Sharing examples and knowledge in a participatory approach
- Getting a common language about NBS
- Going in the field and sharing experience

1.3 Target audience

As mentioned in the introduction, the deployment of nature-based solutions encompasses various fields, including urban planning, health, ecology, public service management, landscape architecture, hydrologist, etc. Therefore, it is essential to **involve different departments** in the training workshop. It is also an excellent opportunity to include the political side of the decision-making process and external partners (both existing or potential). In order to encourage exchanges between participants, we recommend that the number of participants should be between 10 and 20 participants. Interactive polling and gamification tools can be use to help the participatory process³.

Target audience

- Decision-makers and elected representatives

³https://moodle.fct.unl.pt/pluginfile.php/430589/mod_resource/content/3/Interactive%20Polling%20and%20Gamification%20Tools.pdf

- Technicians from various departments such as urban planning, environment, green areas, groundwater protection, road development, mobility, economic development, communication, education, or citizen involvement
- External partners, such as environmental NGO, developers, citizen associations, consulting firms, and businesses...

2 PROGRAMME OF A NBS TRAINING WORKSHOP

Although the trainings have a common thread, each should be adapted to its audience and the local context. The participants' opinions and use them as a basis for adapting the training and developing it further

Example of questions to ask when organising a training workshop

- What are the most relevant topics to be addressed during the training? (flood management, ecological management of green spaces, green roofs, NBS and urban planning...)
- What kind of material should be provided to the technicians? (online resources, videos, scientific literature...)
- What participatory tools could be used? (citizen science, workshops, world café?)
- How long should the training program last? (1/2 day? 1 day?)

2.1 Theoretical reminder

Depending on the level of knowledge of the participants, theoretical reminders on nature-based solutions can be conducted for half or a full day. Presentations should define the concept of NBS, explain scientific insights about their benefits, why biodiversity is important for their design and management and to share practical experiences. Sharing case studies is an excellent way to make the training more concrete and practical. These could be local case studies or from other cities or countries. The idea is to make the theoretical messages clear and to give ideas for implementation.

The PowerPoint presentation is not the only tool available to the presenters. The use of videos, sound documents such as podcasts, and the use of whiteboards or paperboards helps to support changes in pace and different activities.

2.2 Time for group discussions

The discussion between participants is essential during training workshops. They have to be taken into account during the event preparation. Time for group discussions may be formal (workshop activities) or informal (during coffee break, lunch, field trips). They provide good opportunities for participants to get to know each other, exchange ideas and information. In addition, discussion time help to consolidate learning. Here some ideas to boost time for exchanges:

- “Get to know each other”: save time to give the opportunity of each participants to introduce themselves (professional background, working missions, training expectations).
- “Focus group”: it is working workshops in small group to facilitate discussion and make it easier for reserved people to express themselves. Focus group, also facilitate interaction between the different sub-groups at the time of the feedback.

- “Wrap-up”: save time for a wrap-up session to exchange about the format and highlights of the workshop. During this time, participants evaluate their progression, share their objectives of collaboration (between departments or stakeholders), their ideas of new projects and to draw out specific learning.

The trainings should have a top-down (from the scientists to the participants) and a bottom-up (from the participants to the scientists) component. These trainings should present many illustrated examples and practical cases, which can be commented on and criticised in relation to the local expectations of the participants. “Proof by example” is a way of encouraging local actors to reproduce this type of approach at home, saying to themselves that “it is possible elsewhere, so why not in my city”. Many platforms offer feedback and case studies (see below).

It is important to emphasise the success factors of the projects but also the failures in order to overcome them. For example, by indicating what the decision-making process was, what made it possible to start the project, but also what the possible obstacles and barriers were.

The training courses should contain thematic workshops on a theme of importance to the city being trained. This can refer to water management, heat management, or a specific area such as the greening of buildings. In these training sessions, the city's actors must take the floor to present the local context and the functioning of the city (services, planning and urbanism documents, means allocated to management and maintenance), in order to better target expectations.

Prior to the training, a preparation phase is absolutely necessary. It aims to adapt the needs to the target audience and to get to know the participants better. Several stages can be respected:

- Co-organisation between the experts and the city being trained
- Adapt the time and programme to the participants' agenda: the training should not be too long (1.5 days maximum), nor too top-down (1/2 day maximum). Field trips should be planned. Break times are also important as they allow for informal discussion.
- Ice breakers can be used at different times during the training to encourage people to speak out.
- Following the training, a debriefing time is necessary to take stock of the day and gather impressions.
- A second post-training evaluation is also necessary

2.3 Field trips

Field trips are very appreciated during training workshops. They are an opportunity to exchange ideas, in a more free and less formal way, and to come up with new ones. Field trip is the concrete part of the training. It is possible to go and see projects that have already been done or are underway. It also could be walk across the city to identify what the municipality does well, less well, could improve or implement regarding NBS.



Figure 1. Field trip organized for Aarhus workshop training ©Marc Barra



Figure 2. Field trip organized for Velika Gorica workshop training ©Marc Barra

2.4 Agenda from Aarhus and Velika Gorica workshop training

Slides from the workshop held in Aarhus in October 2022 are available in appendix 1.



Tuesday 4th October 2022

Programme

8.30 - Opening remarks (Get to know each other + Objectives of the session)

9.00 - Nature-based solutions: definition, case studies and scientific literature, The importance of biodiversity to design

9.30 - Focus group

- FOCUS 1: Depaving and renaturing
- FOCUS 2: green space management and ecological quality
- FOCUS 3: Green roofs

11.00 - Aarhus case: overview of challenges regarding NBS

13.00 - Field trip

16.15 - Coffee and Wrap up

Figure 3. Aarhus programme



Day 1 – 23.03.2023

09:00. Gathering & morning coffee

09:30. Opening and get to know each other

10:00. Nature-based solutions: Regreens take

10:30. Velika Gorica green infrastructure and NBS development

Short brake

11:00. FOCUS 1: Depaving and renaturing

11:30. FOCUS 2: Green space and ecological quality

Short brake

12:00. FOCUS 3: Green roofs & facades

12:30. FOCUS 4: Water management through NBS

13:00. Exchanges around a meal

Day 2 – 24.03.2023

09:00 – 12:00. Field trip

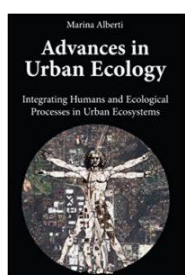
Figure 4. Velika Gorica programme

3 TRAINING TOOLKIT

The training kit suggested below may be useful to enrich the content of the theoretical part and to be shared with the participants to deepen their knowledge of NBS. This bibliography brings together key references to understand the issues related to nature-based solutions for cities and land use planning.

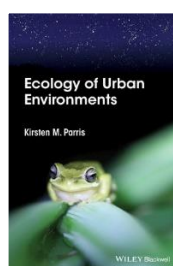
3.1 Books of reference

Urban ecology



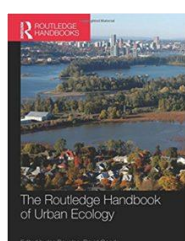
Advances in Urban Ecology: Integrating Humans and Ecological Processes in Urban Ecosystems

Marina Alberti, Springer, December 2008.



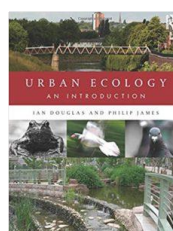
Ecology of Urban Environments

Kirsten M. Paris. Wiley-Blackwell, May 2016



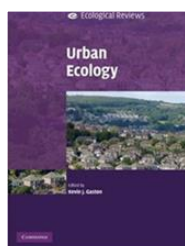
The Routledge Handbook of Urban Ecology

Ian Douglas, David Goode, Mike Houck, Rusong Wang. Routledge, March 2015



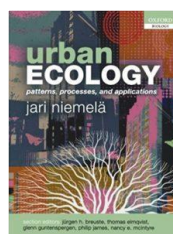
Urban Ecology: An Introduction, 1st edition

Ian Douglas & Philip James. Routledge, January 2015



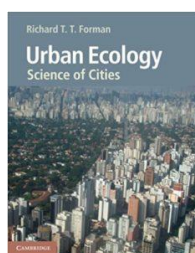
Urban Ecology (Ecological Reviews)

Kevin J. Gaston (editor). Routledge, March 2015



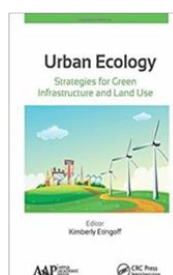
Urban Ecology: Patterns, Processes, and Applications

Niemela, Breuste, Guntenspergen, Mylntyre, Elmqvist, and James. Oxford University Press, January 2012



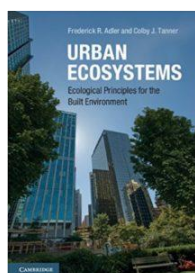
Urban Ecology: Science of Cities, 1st edition

Richard T.T. Forman. Cambridge Univ. Press, April 2014



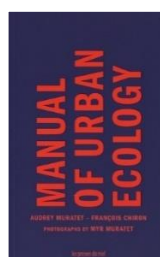
Urban Ecology: Strategies for Green Infrastructure and Land Use

Kimberly Etingoff, Apple Academic Press, July 2015



Urban Ecosystems: Ecological Principles for the Built Environment, 1st edition

Frederick R. Adler and Colby J. Tanner. Cambridge Univ. Press, June 2013



Manual of Urban Ecology

Audrey Muratet, François Chiron, Myr Muratet. 2019

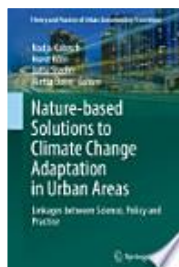
Urban nature-based solutions



Nature-Based Solutions for More Sustainable Cities: A framework approach for planning and evaluation
Edoardo Croci, Benedetta Lucchitta · 2021



Nature-based Solutions for Sustainable Urban Planning
Israa H. Mahmoud, Eugenio Morello, Fabiano Lemes de Oliveira · 2022



Nature-Based Solutions to Climate Change Adaptation in Urban Areas
Nadja Kabisch, Horst Korn, Jutta Stadler · 2017



Urban Sustainability Transitions
Niki Frantzeskaki, Vanesa Castán Broto, Lars Coenen · 2017



Nature-Based Solutions (NBS) in Cities and Their Interaction with Urban Land, Ecosystems, Built Environment and People
Dagmar Haase, Annegret Haase, Manuel Wolff · 2021

3.2 Scientific literature

General articles

[Global mapping of urban nature-based solutions for climate change adaptation](#)

Goodwin, S. *et al.* | Nature Sustainability | 2023
| [Abstract](#)

[What do we mean by justice in sustainability pathways? Commitments, dilemmas, and translations from theory to practice in nature-based solutions](#)

Wijsmana, K. & Berbés-Blázquez, M. | Environmental Science & Policy | 2022
| [Abstract](#)

[Nature-based solutions for climate change adaptation: A systematic review of systematic reviews](#)

Johnson, B. A. *et al.* | Nature-Based Solutions | 2022
| [Abstract](#)

[Governing for Transformative Change across the Biodiversity-Climate-Society Nexus](#)

Pascual, U. *et al.* | BioScience | 2022 | [Abstract](#)

[A conceptual model of the social–ecological system of nature-based solutions in urban environments](#)

Tzoulas, K. *et al.* | Ambio | 2021 | [Abstract](#)

[Nature-Based Solutions to 21st Century Challenges](#)

Brears, R. | Routledge | 2020 | [Abstract](#)

[Nature-based innovation systems](#)

Van der Jagt, A. P. N. *et al.* | Environmental Innovation and Societal Transitions | 2019
| [Abstract](#)

[Working on the boundaries - How do science use and interpret the nature-based solution concept?](#)

Hanson, H. I. *et al.* | Land Use Policy | 2019
| [Abstract](#)

Urban Planning

[Ecosystem Services Analysis and Design through Nature-Based Solutions in Urban Planning at a Neighbourhood Scale](#)

Semeraro, T. et al. | Urban Science | 2022 | [Abstract](#)

[Building urban resilience with nature-based solutions: How can urban planning contribute?](#)

Bush, J. & Doyon, A. | Cities | 2019 | [Abstract](#)

[Key Enablers of and Barriers to the Uptake and Implementation of Nature-Based Solutions in Urban Settings: A Review](#)

Ershad Sarabi, S. et al. | Resources | 2019 | [Abstract](#)

Citizen engagement and governance

[Guidelines for Citizen Engagement and the Co-Creation of Nature-Based Solutions: Living Knowledge in the URBiNAT Project](#)

Nunes, N., et al. | Sustainability | 2021 | [Abstract](#)

[Stewardship Innovation: The Forgotten Component in Maximising the Value of Urban Nature-Based Solutions](#)

Nash, C. et al. | Urban Services to Ecosystem | 2021 | [Abstract](#)

[The Circular Benefits of Participation in Nature-Based Solutions](#)

Cárdenas, M. L., et al. | Sustainability | 2022 | [Abstract](#)

[Environmental and climate policy integration: Targeted strategies for overcoming barriers to nature-based solutions and climate change adaptation](#)

Wamsler, C. et al. | Journal of Cleaner Production | 2020 | [Abstract](#)

[Governance of nature-based solutions through intermediaries for urban transitions – A case study from Melbourne, Australia](#)

Frantzeskakia, N. and Bush, J. | Urban Forestry & Urban Greening | 2021 | [Abstract](#)

[Re-orienting nature-based solutions with more-than-human thinking](#)

Maller, C. | Cities | 2021 | [Abstract](#)

[Beyond participation: when citizen engagement leads to undesirable outcomes for nature-based solutions and climate change adaptation](#)

Wamsler, C. et al. | Climatic Change | 2019 | [Abstract](#)

[Social-ecological and technological factors moderate the value of urban nature](#)

Keeler, B. L. et al. | Nature Sustainability | 2019 | [Abstract](#)

Monitoring

[Assessing urban ecosystem services to prioritise nature-based solutions in a high-density urban area](#)

Balzan, M. V., et al. | Nature-Based Solutions | 2021 | [Abstract](#)

[Nature-Based Solutions as Tools for Monitoring the Abiotic and Biotic Factors in Urban Ecosystems](#)

Larcher, F. et al. | Urban Services to Ecosystems | 2021 | [Abstract](#)

Water management

[Identifying barriers for nature-based solutions in flood risk management: An interdisciplinary overview using expert community approach](#)

Raška, P., et al. | Journal of Environmental Management | 2022 | [Abstract](#)

[Urban governance and policy mixes for nature-based solutions and integrated water policy](#)

Kirsop-Taylor, N. et al. | Journal of Environmental Policy & Planning | 2021 | [Abstract](#)

[A systematic review of the human health and social well-being outcomes of green infrastructure for stormwater and flood management](#)

Venkataramanan, V. et al. | Journal of Environmental Management | 2019 | [Abstract](#)

[Hydro-meteorological risk assessment methods and management by nature-based solutions](#)

Sahani, J. et al. | Science of the Total Environment | 2019 | [Abstract](#)

[Evaluating natural infrastructure for flood management within the watersheds of selected global cities](#)

Gunnell, K. et al. | Science of the Total Environment | 2019 | [Abstract](#)

[Constructed Wetlands for Resource Recovery in Developing Countries](#)

Avellán, T. and Gremillion, P. | Renewable and Sustainable Energy Reviews | 2019 | [Abstract](#)

Urban forests

[Global urban reforestation can be an important natural climate solution](#)

Teo, H. C. et al. | Environmental Research Letters | 2021 | [Abstract](#)

[Can Trait-Based Schemes Be Used to Select Species in Urban Forestry?](#)

Watkins, H. et al. | Frontiers in Sustainable Cities | 2021 | [Abstract](#)

[A review of nature-based solutions for urban water management in European circular cities: a critical assessment based on case studies and literature](#)

Volkán Oral, H. et al. | Blue-Green Systems | 2020 | [Abstract](#)

Health and well being

[Nature-Based Solutions and Protected Areas to Improve Urban Biodiversity and Health](#)

MacKinnon, K. et al. | Biodiversity and Health in the Face of Climate Change | 2019 | [Abstract](#)

[A systematic review of the human health and social well-being outcomes of green infrastructure for stormwater and flood management](#)

Venkataramanan, V. et al. | Journal of Environmental Management | 2019 | [Abstract](#)

[Ecosystem-based adaptation to climate change: concept, scalability and a role for conservation science](#)

Scarano, F.R. | Perspectives in Ecology and Conservation | 2017 | [Abstract](#)

[Cascades of green: A review of ecosystem-based adaptation in urban areas](#)

Brink, E. et al. | Global Environmental Change | 2016 | [Abstract](#)

[A Socio-Ecological Approach for Identifying and Contextualising Spatial Ecosystem-Based Adaptation Priorities at the Sub-National Level](#)

Bourne, A. et al. | PloS one | 2016 | [Abstract](#)

[Operationalizing ecosystem-based adaptation: harnessing ecosystem services to buffer communities against climate change](#)

Wamsler, C. et al. | Ecology and Society | 2016 | [Abstract](#)

[Integrated valuation of a nature-based solution for water pollution control. Highlighting hidden benefits](#)

Liquete, C. et al. | Ecosystem Services | 2016 | [Abstract](#)

3.3 Technical guides

Planning for NBS

[Making Nature's City: A science-based framework for building urban biodiversity](#)
Spotswood, E.N., et al | Report from The San Francisco Estuary Institute | 2019

[Adaptation Gap Report 2020, chapter 6 "Nature-based solutions for adaptation »](#)
Fifth edition of the UNEP Adaptation Gap Report

Water management

[Urban wetland design guide designing wetlands to improve water quality](#)
Ian Russell, London Borough of Enfield, with support from Joe Pecorelli and Azra Glover of ZSL

[Ponds and wetlands](#)
Cambridge SUDS Design & Adoption Guide

[Design guidelines for urban stormwater wetlands](#)
Celina Balderas Guzmán, Heidi Nepf, Alan M. Berger, 2018

Urban heat management

[Nature Based Solutions for Heat Wave Management in cities](#)
Magotra, R. et al. | Integrated Research and Action for Development (IRADe)

[Trees for a Cool City: Guidelines for optimised tree placement](#)
Andrew Coutts and Nigel Tapper | CRC for Water Sensitive Cities, School of Earth, Atmosphere and Environment Monash University | 2017

Green buildings

[Ecology of green roof. Summary of the GROOVES \(Green roofs verified ecosystem services\)](#)
Barra, M. et al. | Study from ARB îdF | 2021

Depaving and Renaturing

[Guidelines for a "depaving" and "re-greening" strategy in cities](#)
Deboeuf, G., et al. | Deliverable N°3.2 of the REGREEN project

[Potential for the Removal of Impervious Soil Coverage 2021](#)
Berlin environmental Atlas | Guide continually updated

3.4 MOOC



[Urban Nature MOOC](#)

The NATURVATION project launched a Massive Open Online Course (MOOC) on nature-based solutions in an urban world in January 2020. The MOOC contains a collection of inspiring and educational films about the opportunities, challenges and future of nature-based solutions. The aim of the course is to develop an online learning community around nature-based solutions in cities.



[Nature Based Metropolitan Solutions](#)

This course establishes the priorities and highlights the direct values of including principles based on natural processes in urban planning and design. Take a sewage system or a public space for example. By integrating nature-based solutions they can deliver the exact same performance while also being beneficial for the environment, society and economy.



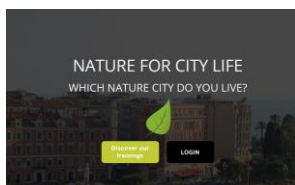
[Nature-based Solutions for Disaster and Climate Resilience](#)

It is a massive open online course from UN Environment Programme (UNEP) and the Partnership for Environment and Disaster Risk Reduction (PEDRR). This course establishes the guidance on how to apply NBS in enhancing resilience. It explains how human activities are interlinked with ecological systems and how including nature as a solution in policy processes.



[Nature-based Urban Regeneration](#)

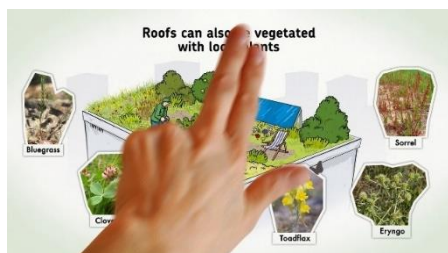
How can we use nature to improve life in our cities? This course shares knowledge generated in urban Living Labs in Europe and China and will introduce you to co-designing, co-implementing and evaluating nature-based solutions for urban renewal with local communities. Learn how to set up your own nature-based regeneration strategy.



[Nature for city life](#)

This MOOC is developed within the framework of the Nature for City LIFE project. This multi-partner project, led by the South Provence-Alpes-Côte d'Azur Region, aims to develop and enhance the value of nature in cities to strengthen the attractiveness of territories and adapt to climate change by relying on two operational objectives : 1) inform, raise awareness and train different audiences and actors on the services provided by nature in cities ; 2) reinforce the integration of nature in the city in urban development projects

3.5 Videos



[Climate : Nature-based solutions for climate change mitigation and adaptation in Paris Region](#)

This film aims at explaining and illustrating Nature-based solutions for Paris Region. Solutions for the preservation, sustainable use and restoration of ecosystems and biodiversity, with the dual objective of mitigating climate change and adapting Paris region to its effects.

Its contents draw upon the work of several different bodies, including the regional Agency for Biodiversity in Paris region (ARB Île-de-France) itself but also those who participated in the ARB Île-de-France/ GIS Environment-Society / Seine-Normandie Water Agency symposium held on September 29th-30th 2015. These propositions are the Agency's contribution for discussion at the 21st session of the Conference of the Parties on Climate Change (COP21)



[Ecological management: Let's bring biodiversity to cities](#)

The city is a mosaic of open spaces dedicated to a variety of uses. The way these spaces are managed can have impacts on the environment. For example, the use of pesticides has an impact on air, water, soils, human health. Since 1 January 2017, the use of chemical pesticides has been prohibited in some public spaces. Let's go further, let's learn to do without all products that are harmful to the environment everywhere. From the most intensively maintained to the most natural, let's switch to differentiated management. In

recent years, more and more local authorities and companies have been turning to ecological management initiatives. Let's adopt practices favourable to biodiversity by planting local species adapted to the climate, diversifying plant heights and environments, Let's preserve soils and water by the use of mulching and ground cover, reducing the drying effects of the wind and sun and promoting water storage and release.



[Environnemental grids : countless benefits for humans](#)

Urbanization and intensive agricultural practices consume and fragment natural environments. Species find themselves trapped and weakened. Their survival depends on a continuous network of corridors and reservoirs of biodiversity: these are the "green, blue, brown and black" frames. These ecological networks also bring significant benefits to humans. This film was produced by the Joint

Union for the Development of the Bourbre Basin (EPAGE de la Bourbe), in partnership with the Regional Biodiversity Agency in Île-de-France, the Rhône Méditerranée Corse Water Agency, the Direction of Innovation and Education of the Ministry of Ecological Transition in France (IPEC), and the European Union.



[Agriculture and biodiversity, growing with nature](#)

The Paris Region Biodiversity Agency invites you to discover its video clip on the relationship between agriculture and biodiversity. Since the second half of the 20th century, national and international policies have encouraged farmers to produce more and at a lower cost. This model, characterized by its high mechanization, the massive use of inputs and the homogenization of landscapes, is now questioned by many farmers. Indeed, they are prisoners of a system that has led them to high-yield practices, endangering the maintenance of biodiversity and traditional landscapes. This is why an increasing proportion of farmers are now turning to an agriculture based on the understanding of ecological principles: they work with soil biodiversity, preserve the quality of water, rely on pest predators, favor protect wild pollinators; they plant hedgerows, restore ponds, sow flowering meadows and adopt practices to reintroduce wild or cultivated biodiversity at all scales. This clip looks back at the impacts of intensive agriculture on wildlife and presents some agricultural practices that use and protect the biodiversity at the same time. Its purpose is to raise awareness and encourage farmers to move forward virtuous practices, but also to invite consumers and convince private and public actors to support these farmers in order to change agricultural models in the Paris region.



[Urbanism, architecture and biodiversity : when nature inspires cities and buildings](#)

Since 2008, the regional agency for biodiversity in Paris region (ARB Île-de-France) aims at involving local actors to act on biodiversity issues, particularly in terms of knowledge and regarding actions in urban planning, agriculture or construction. The decline of biodiversity in urban areas invites us to imagine innovative solutions to manage, build, renovate and promote biodiversity in urbanism and architecture. Solutions exist on every scale. To better understand these solutions, we produced the video "Urbanism, architecture and biodiversity: when nature inspires cities and buildings". It is made to provide cities, architects, land planners or the building sector with solutions to develop green infrastructure and solutions for eco-cities and eco-buildings.

3.6 Podcasts



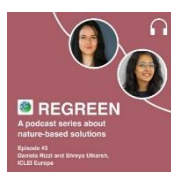
Episode 1: Bringing nature to everybody. What are nature-based solutions, and what is the REGREEN project about?

In this episode we interview Senior researcher from Aarhus University, Marianne Zandersen, who is coordinating the EU Horizon2020 project, REGREEN.



Episode 2: ULL Aarhus - water challenges and afforestation projects. What climate challenges is an old city like Aarhus in Denmark facing, and how does rapid citizen growth impact sustainable urban development?

In this episode we interview Landscape Manager, Signe Marie Iversen, and Forest and Landscape Engineer, Gorm Halskov, from the REGREEN Urban Living Lab, Aarhus Municipality.



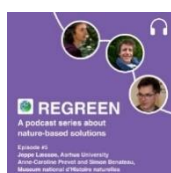
Episode 3: Nature-based solutions and the UN Sustainable Development Goals. How and why are nature-based solutions interlinked with the UN Sustainable Development Goals?

In this episode, we try to find an answer to this question through a conversation with Shreya Utkarsh and Daniela Rizzi, respectively Officer and Senior for Nature-Based Solutions, Green Infrastructures and Biodiversity at ICLEI Europe.



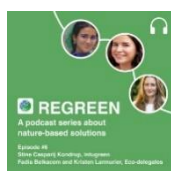
Episode 4: ULL Paris Region - the Seine, the Eiffel Tower and the restoration of biodiversity. Which effect does heavy urbanization have on biodiversity? And which potential does a big river like the Seine have in a city like Paris?

In this episode, we explore the French capital region with ecologist Marc Barra, from Institut Paris Region, and hydraulic engineer Eric Chanal, general director of the SIAH, Mixed union for the Hydraulic Development of the valleys of the Croult and the Petit Rosne.



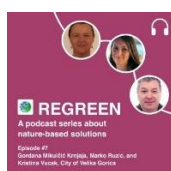
Episode 5: Citizen science, how to increase critical thinking about nature, biodiversity and nature-based solutions. How can citizen science help us learn about nature? And which role does citizen science play within the REGREEN project?

In this episode, we get to dive into the concept of citizen science, its possibilities and its potential. Our guides are Jeppe Læssøe from Aarhus University, along with Anne-Caroline Prevot and Simon Benateau from Muséum nationale d'Histoire naturelle, Paris.



Episode 6: Kids and nature learning - how young people can be involved in the greening of our cities. Why is it important to involve kids and young people in making our cities green and welcoming? And how do we do it?

In this episode, Stine Casparij Kondrup from Intugreen explains why it is important to engage young people in the process of sustainable urban development. She is joined by elected eco-delegates Kristen Larmurier and Fadia Belkacem who share their experiences and thoughts on the subject from their high school in Paris.



Episode 7: ULL Velika Gorica - how the forest can both be part of the problem and especially an important part of the solution. What kind of challenges is the little Croatian city facing? And how can planting trees be part of the solution to all of them?

In this episode, Gordana Mikulčić Krnjaja, Head of department for Spatial planning and Environmental Protection, Marko Ruzic, Consultant for environmental protection, and Kristina Vucak, Senior expert associate for landscaping, take us through the challenges and solutions of the small Croatian city of Velika Gorica.



Episode 8: ULL Beijing - the green side of a huge city. How does one of the biggest and most populous cities in the world manage to have an urban green space of 51% and increasing?

In this eight and final episode, we discover the green side of the metropolis Beijing with Jun Yang, Professor of Ecology from Tsinghua University. We learn about some of the climate challenges Beijing is facing, how nature-based solutions are used actively to prevent flooding, heat islands, and other challenges. And we get an introduction to the differences and similarities between the Chinese and the European perception of nature.

3.7 H2020 Project and NBS

Demonstrating innovative nature-based solutions in cities

Project name	Website	CORDIS page	Full name	Years
CLEVER Cities	https://clevercities.eu/	https://cordis.europa.eu/project/id/776604	Co-designing Locally tailored Ecological solutions for Value added, socially inclusive Regeneration in Cities	2018-2023
Connecting Nature	https://connectingnature.eu/	https://cordis.europa.eu/project/id/730222	COproductionN with Nature for City Transitioning, INnovation and Governance	2017-2022
EdiCitNet	https://www.edicitnet.com/fr/media/deliverables/	https://cordis.europa.eu/project/id/776665/fr	Edible Cities Network Integrating Edible City Solutions for social resilient and sustainably productive cities	2018-2023
GrowGreen	https://growgreenproject.eu/	https://cordis.europa.eu/project/id/730283	Green Cities for Climate and Water Resilience, Sustainable Economic Growth, Healthy Citizens and Environments	2017-2022
proGInreg	https://progireg.eu/	https://cordis.europa.eu/project/id/776528	productive Green Infrastructure for post-industrial urban regeneration	2018-2023
UNaLab	https://unalab.eu/en	https://cordis.europa.eu/project/id/730052	Urban Nature Labs	2017-2022
Urban GreenUP	https://www.urbangreenup.eu/	https://cordis.europa.eu/project/id/730426	New Strategy for Re-Naturing Cities through Nature-Based Solutions	2017-2023
URBiNAT	https://urbinat.eu/	https://cordis.europa.eu/project/id/776783	Healthy corridors as drivers of social housing neighbourhoods for the co-creation of social, environmental and marketable NBS	2018-2023

Inter-relations between climate change, biodiversity and ecosystem services

Project name	Website	CORDIS page	Full name	Years
DRYvER	https://www.dryver.eu/	https://cordis.europa.eu/project/id/869226	Securing biodiversity, functional integrity and ecosystem services in DRYing rivER networks	2020-2024
FutureMARES	https://www.futuremares.eu/	https://cordis.europa.eu/project/id/869300	Climate Change and Future Marine Ecosystem Services and Biodiversity	2020-2024
PONDERFUL	https://ponderful.eu/	https://cordis.europa.eu/project/id/869296	POND Ecosystems for Resilient Future Landscapes in a changing climate	2020-2024
MaCoBioS	https://macobios.eu/	https://cordis.europa.eu/project/id/869710	Marine Coastal Ecosystems Biodiversity and Services in a Changing World	2020-2025

Large-scale demonstrators on nature-based solutions for hydro-meteorological risk reduction

Project name	Website	CORDIS page	Full name	Years
OPERANDUM	https://www.operandum-project.eu/	https://cordis.europa.eu/project/id/776848	OPEn-air laboRAtoRies for Nature based solUtions to Manage hydro-meteo risks	2018-2022
PHUSICOS	https://phusicos.eu/	https://cordis.europa.eu/project/id/776681	According to nature' - solutions to reduce risk in mountain landscapes	2018-2023
RECONNECT	http://www.reconnect.eu/	https://cordis.europa.eu/project/id/776866	Regenarating ECOsystems with Nature-based solutions for hydro-meteorological risk rEduCTion	2018-2024

Multi-stakeholder dialogue platform to promote innovation with nature to address societal challenges

Project name	Website	CORDIS page	Full name	Years
ThinkNature	https://www.think-nature.eu/	https://cordis.europa.eu/project/id/730338	Development of a multi-stakeholder dialogue platform and Think tank to promote innovation with Nature based solutions	2016-2019

New governance, business, financing models and economic impact assessment tools for sustainable cities with nature-based solutions (urban re-naturing)

Project name	Website	CORDIS page	Full name	Years
Nature4Cities	https://www.nature4cities.eu/	https://cordis.europa.eu/project/id/730468	Nature Based Solutions for re-naturing cities: knowledge diffusion and decision support platform through new collaborative models	2016-2021
NATURVATION	https://www.naturvation.eu/	https://cordis.europa.eu/project/id/730243	Nature Based Urban Innovation	2016-2021

Operationalising insurance value of ecosystems

Project name	Website	CORDIS page	Full name	Years
NAIAD	http://naiad2020.eu/nbs/	https://cordis.europa.eu/project/id/730497	Nature Insurance value: Assessment and Demonstration	2016-2020

Strengthening international cooperation on sustainable urbanisation: nature-based solutions for restoration and rehabilitation of urban ecosystems

Project name	Website	CORDIS page	Full name	Years
CLEARING HOUSE	https://clearinghouseproject.eu/	https://cordis.europa.eu/project/id/821242	Collaborative Learning in Research, Information-sharing and Governance on How Urban tree-based solutions support Sino-European urban futures	2019-2023
REGREEN	https://www.regreen-project.eu/	https://cordis.europa.eu/project/id/821016	Fostering nature-based solutions for smart, green and healthy urban transitions in Europe and China	2019-2023
CONEXUS	https://www.conexusnbs.com/	https://cordis.europa.eu/project/id/867564	CO-producing Nature-based solutions and restored Ecosystems: transdisciplinary neXus for Urban Sustainability	2020-2024
INTERLACE	https://www.interlace-project.eu/	https://cordis.europa.eu/project/id/869324	INTERNational cooperation to restore and connect urban environments in Latin America and Europe	2020-2024

Twinning

Project name	Website	CORDIS page	Full name	Years
RENATURE	https://renature-project.eu/	https://cordis.europa.eu/project/id/809988	Promoting Research Excellence in Nature-based solutions for innovation, sustainable economic Growth and human well-being in Malta	2018-2021

Visionary and integrated solutions to improve well-being and health in cities

Project name	Website	CORDIS page	Full name	Years
EuPOLIS	https://eupolis-project.eu	https://cordis.europa.eu/project/id/869448	Integrated NBS-based Urban Planning Methodology for Enhancing the Health and Well-being of Citizens: the euPOLIS Approach	2020-2024
GO GREEN ROUTES	https://www.ul.ie/covid/news/go-green-ul-leads-eu105-eu-project-to-transform-environmental-and-human-health	https://cordis.europa.eu/project/id/869764	GO GREEN: Resilient Optimal Urban natural, Technological and Environmental Solutions	2020-2024

3.8 Technical Handbook from previous European projects

[Unalab NBS technical handbook factsheets](#)

The UNaLab NBS Technical Handbook Factsheets aim to provide inspiration and easily digestible information directed towards practitioners on a range of nature-based solutions (NBS). The handbook does not aim to offer an exhaustive list and summaries of all existing NBS

[Thinknature handbook](#)

This Handbook has been developed in the framework of the ThinkNature project. Its main objective is to gather and promote state-of-the-art knowledge regarding Nature-Based Solutions (NBS), comprising a comprehensive guide to all relevant actors

[Connecting nature framework guidebook](#)

Connecting Nature has developed an introductory guidebook to the overall Connecting Nature Framework and a series on each of the individual elements to assist you to develop your nature-based solutions.

[Nature4Cities Handbook](#)

Nature4Cities is a Horizon 2020 EU-funded Research & Innovation project, creating a comprehensive reference Platform for Nature Based Solutions (NBS), offering technical solutions, methods and tools to empower urban planning decision making. This will help addressing the contemporary environmental, social and economic challenges faced by European Cities.

[The GREEN SURGE Handbook](#)

This handbook is focused on how Urban Green Infrastructure can contribute to a sustainable future for cities by addressing major urban challenges. The challenges are related to land use conflicts, biodiversity conservation, climate change, demographic changes, a greener economy, and human health and wellbeing.

3.9 Nature-Based solutions platforms

[OPPLA - Information hub for nature-based solutions](#)

Oppla is a virtual hub where the latest thinking on nature-based solutions is brought together from across Europe. Oppla will provide access to a wide range of resources, drawn from the most innovative communities of science, policy and practice.

[NetworkNature](#)

NetworkNature is a resource for the nature-based solutions community, creating opportunities for local, regional and international cooperation to maximise the impact and spread of nature-based solutions. The project is funded by the European Commission under the Horizon 2020 programme.

[Climate-ADAPT](#)

Climate-ADAPT aims to support Europe in adapting to climate change helping users to access and share data and information on: expected climate change in Europe; EU, national and transnational adaptation strategies and actions; adaptation case studies and potential adaptation options, etc.

[weADAPT](#)

weADAPT is a collaborative platform on climate change adaptation issues. It allows practitioners, researchers and policy-makers to access credible, high-quality information and connect with one another.

[Urban Nature Atlas](#)

The Urban Nature Atlas developed as part of the [Naturvation](#) project. UNA is collection of more than 1000 inspiring nature-based solutions from European cities and beyond Nature-based solutions are defined as human-made projects that are either inspired by, or supported by, nature. These projects can take many forms, from installation of green roofs or walls to inclusion of natural assets into urban parks or blue areas, for example through riverbank renovations.

[Panorama](#)

PANORAMA – Solutions for a Healthy Planet is a partnership initiative to document and promote examples of inspiring, replicable solutions across a range of conservation and sustainable development topics, enabling cross-sectoral learning and inspiration. PANORAMA is collection of more than 1000 successful examples across mitigation, conservation, one health, restoration projects.

[BISE](#)

The Biodiversity Information System for Europe (BISE) is a single entry point for data and information on biodiversity in the EU. Bringing together facts and figures on biodiversity and ecosystem services, it links to related policies, environmental data centres, assessments and research findings from various sources. It is being developed to strengthen the knowledge base and support decision-making on biodiversity

[Climatescan](#)

ClimateScan is an interactive web-based map application for knowledge exchange on (over 5000 in 2020) 'blue-green' projects mostly on urban resilience, climate proofing and climate change adaptation (CCA) around the globe, with a good European coverage.

[Nature based solutions platform](#)

The overall aim of the platform is to consolidate and facilitate access to the large dispersed evidence-base on the effectiveness of NbS for addressing climatic impacts on people and economic sectors, and thereby support global efforts to design and implement robust targets for nature in climate change and development policy. The Nature-based Solutions Evidence Platform is an interactive map linking nature-based solutions to climate change adaptation outcomes based on a systematic review of the peer-reviewed literature.

[Natural Water Retention Measures \(NWRM\)](#)

NWRM is a platform that supports the implementation of the European Environmental Policy on green infrastructure as a way to contribute to integrated goals dealing with nature and biodiversity conservation and restoration, landscaping.

4 SOME TAKE HOME MESSAGES

The objective of this document is to provide ideas for nature-based solutions training and improve their deployment. Feedback from the participants at the Aarhus training workshop highlight the importance in such trainings to share a common language about nature-based solutions, to convince about their benefits, and to constitute a team to improve their implementation. Training workshops is an opportunity to share scientific arguments to convince about the benefits and interest of NBS to reluctant people. As the importance of developing NBS is not shared by every service, this is necessary to involve different services and mix people, including the political side. Workshops help to reduce fears and received ideas currently related to the idea of bringing back nature to the city or giving it more space. To address this issue, it could be relevant to organize such trainings involving the local population.



5 APPENDIX 1 - SLIDES FROM THE WORKSHOP HELD IN AARHUS IN OCTOBER 2022

**REGREEN**
NATURE-BASED SOLUTIONS**ARB**
AGENCE RÉGIONALE
DE LA BIODIVERSITÉ

Training workshop on Nature-based solutions *Aarhus session*

Marc Barra & Gwendoline Grandin - Agency for Biodiversity, Paris Region Institute
Signe Iversen & Hanne Lund Steffensen, Municipality of Aarhus



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no.821016 This document reflects only the author's view and the Commission is not responsible for any use that may be made of the information it contains.



REGREEN H2020 Project (2019-2024)

Fostering nature-based solutions for equitable, green and healthy urban transitions in Europe and China



Objectives: Aims to integrate **knowledge and evidence on benefits** from Nature-based solutions to address urban challenges; **develop and test tools to guide, design and plan** NBS; **consolidate business and investment models** for NBS and promote NBS **awareness and institutionalisation** in education, governance, and planning

Focus on:

- Children & youth's experience & awareness of natural environment & NBS
- Quantifying and modelling ecosystem services from NBS
- Quantifying benefits & values from NBS and their services
- Improve systems of governance and planning
- Business incubation, new financial models, cost-effectiveness & risks
- Exchange of knowledge & experience, training between urban living labs



 twitter.com/REGREEN-nbs

 linkedin.com/company/regreen-horizon-2020

Website: www.regreen-project.eu

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Get to know each other



1'

- Your name
- What is your current position ?
- What is your experience regarding Nature-based solutions ?



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Objectives of the training workshop

- Scientific insights about the benefits of Nature-based solutions
- Why is biodiversity important for NBS design and management
- Focus on green spaces ecological quality
- Focus on green roofs
- Focus on depaving and renaturing cities
- Share examples and knowledge
- Get a common language about NBS
- Go on the field and share experience

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Climate and biodiversity are connected

- Carbon capture and storage
- Biogeochemical and water cycles
- Absorption / reflection of solar radiation
- Terrestrial and marine ecosystems play an important role in regulating climate
- Mitigation of extreme weather events



Climate



Biodiversity



- Temperature
- Precipitation, humidity, wind strength
- Extreme events (drought, flood, etc.)

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- Climate affects biodiversity in many ways: temperature, precipitation, humidity, wind strength, extreme events (drought, flood, etc.), affect ecosystems and species
- Today, climate change is among the most significant threats to biodiversity (in addition to the impacts of human activity), and its effects are likely to grow in intensity over the coming decades
- The thing that we know less is: biodiversity reacts to climate:
- Ecosystems and biodiversity participate directly in climate regulation through: Carbon capture and storage; Biogeochemical cycles; Absorption / reflection of solar radiation: etc.
- So biodiversity and climate are linked, they work together
- So we can't address climate change issue without consider the ecological crisis
- And if we manage/act for biodiversity we can have an impact on climate (That is the purpose of NBS)



Nature-based solutions

Solutions that address both climate and biodiversity challenges while delivering additional benefits for people

They encompass a wide range of actions, such as :

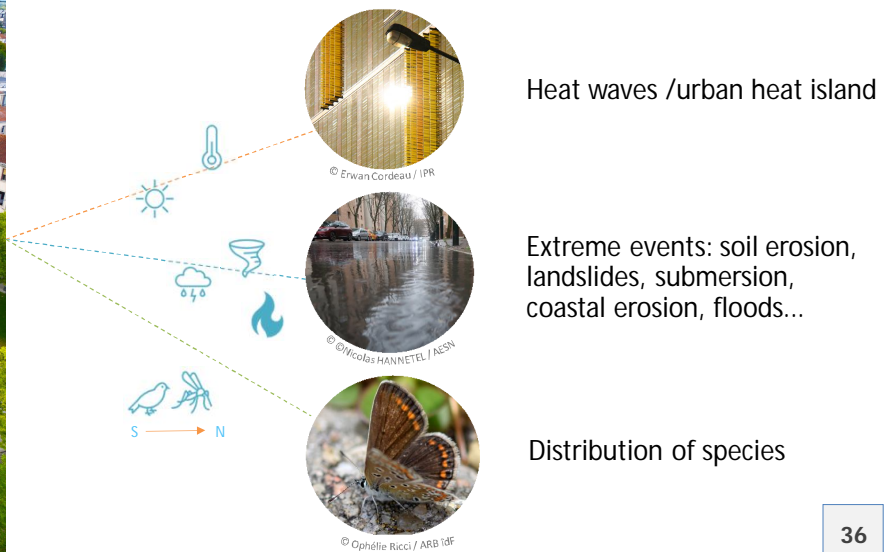
- **Protection** of natural and semi-natural ecosystems,
- **Management** of these ecosystems (or no management)
- **Restoration** and rehabilitation of degraded ecosystems



- NBS are solutions that address both climate & biodiversity challenges, and deliver additional benefits for people
- They encompass a wide range of actions...
- NBS can be applied in urban or natural areas as soon as they are based on ecosystem understanding
- They can be implemented at different scales
- NBS encompass 2 main strategies for dealing with climate change: mitigation and adaptation
 - *ecosystems capture and storage carbon, so they help to attenuate Climate change, this is called mitigation*
 - *Thanks to other ecosystem services it is possible to reduce impacts of climate change, It's what we call adaptation*



Nature-based solutions for climate change adaptation in cities



Heat waves /urban heat island

Extreme events: soil erosion, landslides, submersion, coastal erosion, floods...

Distribution of species

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- This presentation focus on adaption in cities through NBS
- In urban areas, NBS can reduce many effects of climate change such as :
 - Heat waves / heat urban island phenomenon
 - Extreme events like floods, runoff, soil erosion...
 - help species move to the north and to their new bioclimatic areas

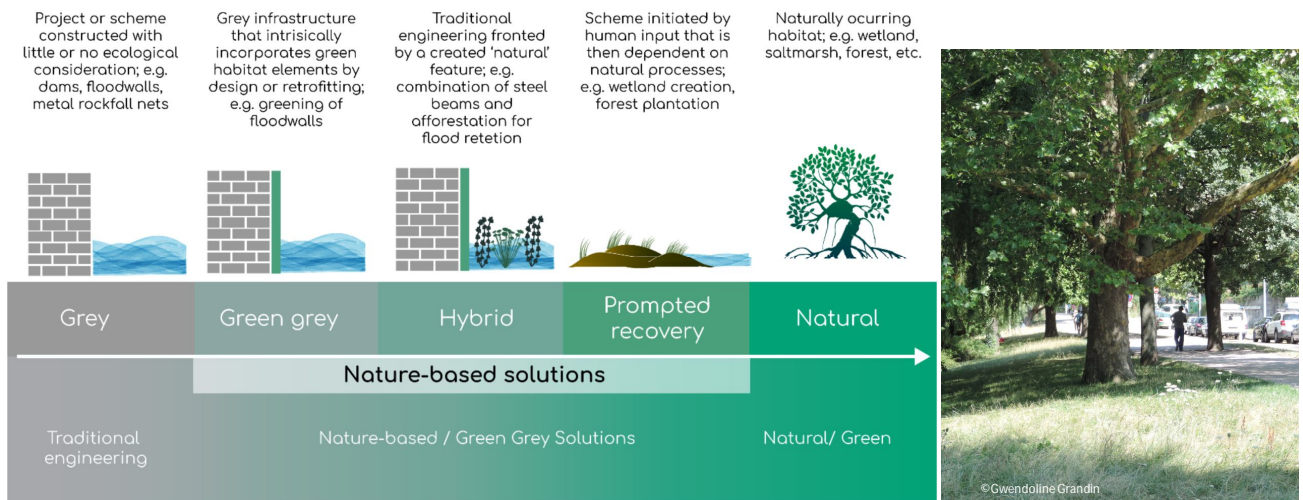
NBS generate multiple co-benefits



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- NBS provides climate and biodiversity benefits but also provides additional benefits such as:
 - economic advantages: NBS are often less expensive than grey infrastructure (like the construction of dykes to protect against flooding)
 - social benefits, health, and environment advantages.

NBS vs grey infrastructure



The grey-green continuum of infrastructure approaches ©Martin, Juliette G. C., Anna Scolobig, JoAnne Linnerooth-Bayer, Wei Liu, and Jörg Balsiger. 2021. "Catalyzing Innovation: Governance Enablers of Nature-Based Solutions" *Sustainability* 13, no. 4: 1971. <https://doi.org/10.3390/su13041971>

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- NBS are multifunction – as opposed to grey infrastructure that only addresses 1 issue
- Grey infrastructure have more impact regarding their entire life cycle
 - Beyond "grey infrastructure", we should consider the impacts of materials on ecosystems and biodiversity on the entire value chain (life cycle) : extraction, production, transformation, transport, end of life (waste)
- For instance : on the left, we can see an experimental column installed in some streets in Paris.
 - Inside there are micro-algae to capture carbon dioxide released by cars.
 - But it is a quite expensive solution (20,000€ and it only captures CO₂)
 - While a tree in the city can capture CO₂ in addition to providing benefits such as: shade, air cooling, air filtration, providing a habitat for species, improving the environment
- Solutions can also be hybrid : a mix of civil and ecological engineering (green facade, green roof)

NBS can replace grey infrastructure



A floodable green space had been designed to replace a rainwater storage tank

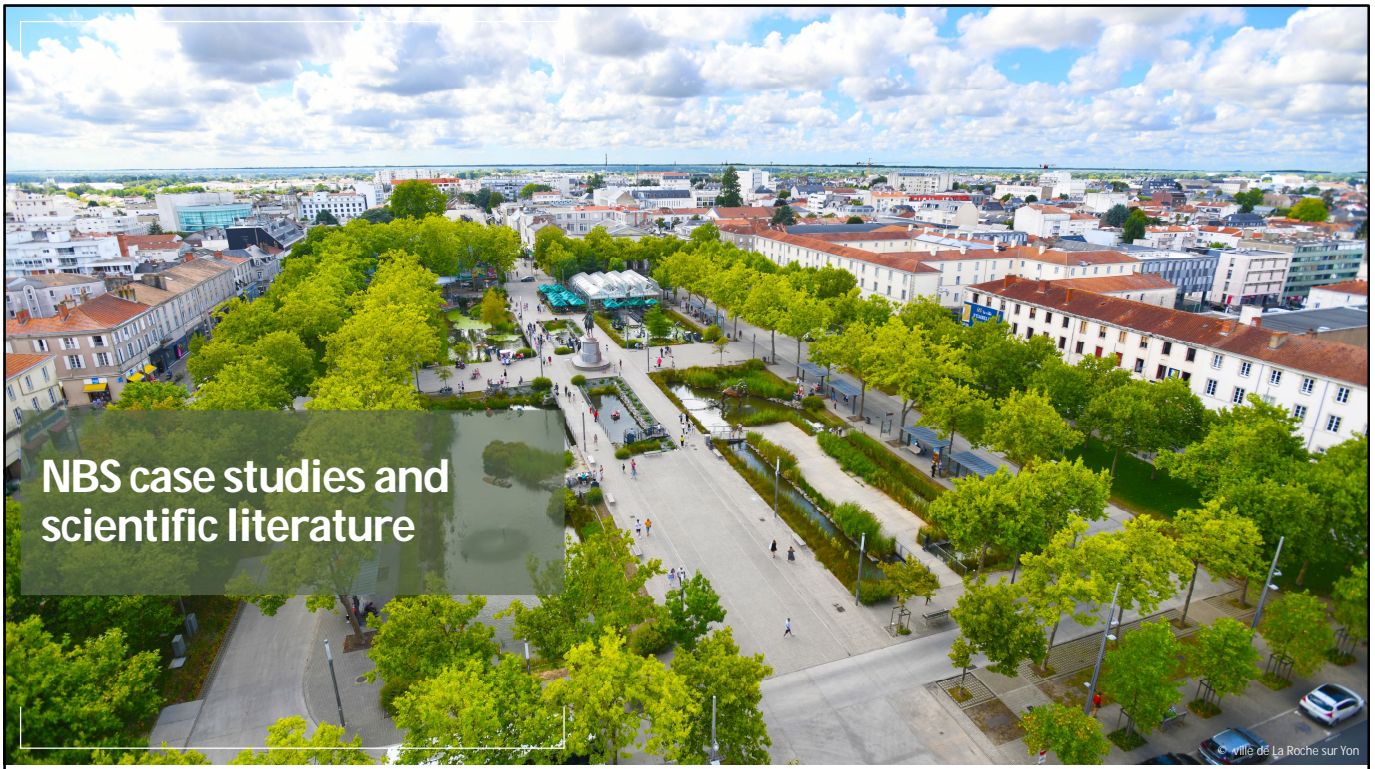
These floodable green spaces were designed :

- to manage urban rainwater,
- increase access to green spaces for the people
- enhance biodiversity through heterogeneous vegetation (dry areas, meadow, wetland) and extensive management.

< Clos Saint-Vincent district in Noisy-Le-Grand (Paris Region)

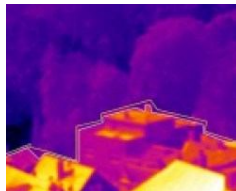
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- Sometimes it is possible to replace **grey infrastructure with NBS**, such as for water management.
- Here is an example in the Paris Region where a rainwater storage tank has been replaced by a floodable green space
- This green space was designed to store urban rainwater, increase access to green spaces for the people and enhance biodiversity through heterogeneous vegetation (dry areas, meadow, wetland) and extensive management.
- The green space has never been completely flooded : water depths do not exceed 50 cm for decennial rainfall. The photo below right was taken after a heavy rain (40mm of water in 13 hours) : the green space has a great capacity of absorption. Heights of water do not cause safety problems
- A study had been carried out for monitoring the [effectiveness](https://pastel.archives-ouvertes.fr/tel-00582379/file/TH2010PEST1051.pdf) of floodable green spaces at the scale of the district Clos Saint Vincent in the city of Noisy le Grand. The study shows that floodable green spaces are effective in reducing runoff, flooding and concentration of some contaminants. The study also points out that the more vegetated the green space, the more efficient it is (run off, water quality, etc.) <https://pastel.archives-ouvertes.fr/tel-00582379/file/TH2010PEST1051.pdf>



Nature-based solutions to reduce urban heat island

Decrease in surface temperatures



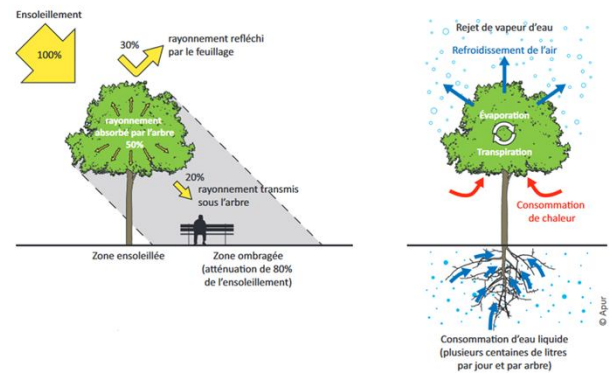
35 °C in the park while buildings exceed 50 °C



40°C difference between the green roof and the conventional roof

The **size** and **composition** of green spaces are also important factors that influence both the cooling effect and how far it extends. A study carried out in London points out that areas of 5 to 15 hectares have a cooling effect of 0.6 to 1 degree that can be measured 180 – 330 metres beyond the study site (Monteiro et al, 2016).

Cooling effect



0.7 - 2°C difference in air temperature between streets without and with trees (Vinet J, 2004). The cooling effect of an isolated mature tree transpiring 450 litres per day from its leaves has been estimated to be equivalent to 5 average size room air conditioners running 20 hours per day (Pitt, D., et al. 1979)

- In cities, paved surface and building absorb sunlight, increasing air T°
- This is one of the main factors of the UHI
- Here some results of surface temperature measurement that show a difference of:
 - 20°C between a park / city
 - 43°C between a green roof / normal roof
- So the cover vegetation decreases surface T° in cities
- Ecosystems have also a cooling effect, but the size and composition of green spaces are 2 important factors that influence:
 - The cooling effects
 - And how far it extends
- A study carried out in London points out that area of 5 to 15 ha have a cooling effect of 0.6 to 1°C that can be measured 180-330 m beyond the study area
- Trees are the most effective to reduce T°, because they provide shade & can cool the air thanks to the evapotranspiration
- A study points out that trees have a local cooling effects of 0.7 to 2 degree and matures trees are the most effective

Cooling effect of vegetation on a dense city street

France, Lyon Metropolitan Council



- As part of its climate plan, the Lyon Metropolitan Council is greening urban space to reduce the effects of urban heat islands.
- 3-km of the Rue Garibaldi was turned into a shaded parkway.
- In periods of extreme heat, evapotranspiration no longer occurs. Giving trees stored rainwater kick-starts evapotranspiration to cool the street.
- According to several measurement campaigns carried out, the trees brought temperatures down an average of 1.78°C to 2.33°C in August 2016 and 2017.
- As for perceived temperatures, the difference between planted and unplanted areas was up to 10°C.

- As part of its climate plan, the Lyon Metropolitan Council is planting tree in urban spaces to reduce UHI
- They turned a 3 km road into a parkway with a lot of trees.
- They had a great idea to store rainwater under the road. Because during periods of extreme heat, evapotranspiration no longer occurs
- They watering trees with the rainwater stored to kickstart the cooling
- Temperature measurement points out that trees have reduced the temperatures by an average of 2 degree during summer
- For perceived temperature, the difference between planted and unplanted areas was up to 10°C
- Lyon Metropole has a long history of associating its climate initiatives with the role of trees and nature across its cityscape. In the “Canopée” (Canopy) project, Lyon has set itself some ambitious goals in adding more shaded areas to respond to the challenge of heat islands. The Metropole is also working to remove impermeability from its urban spaces and to store rainwater and is recognising the importance of diversity by mixing the species of trees planted across its territory. Lyon is running research projects to measure and characterize the capacity of trees to offer natural cooling to residents, while also experimenting with urban soil recovery to stimulate a circular economy.
- https://www.capitale-biodiversite.fr/sites/default/files/experience/documents/metropole_de_lyon_cfb2019.pdf
- <https://use.metropolis.org/case-studies/climate-air-and-energy-territorial-plan>

Nature-based solutions to reduce runoff and flood risk



- Renaturing, remeandering existing watercourses, restoring ecosystems associated with rivers & wetlands.
- Sustainable Urban Drainage systems (SUDS) such as ponds, vegetated ditches or wetlands help reduce runoff. Several publications have shown that these solutions have also the potential to provide a habitat for biodiversity (*Monberg et al, 2019*).
- However specialists have also pointed out the need to improve the design and the management of rainwater systems (improving structural diversity and irregularities on riverbanks, lighter mowing, etc.) so that they have a positive impact on biodiversity (*Oertli et al., 2019*).
- An American study has shown that the trees of New York City help to reduce runoff by an estimated 69 million cubic feet a year (valued at \$4.6 million per year) (*Nowak et al, 2018*).

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- To reduce runoff and flooding, we can renature, remeander water courses, restore wetlands and ecosystems associated with streams
- For example, riparian woodlands help to maintain riverbanks and to slow down river flow
- In cities we also developed Sustainable Urban Drainage Systems such as ponds, vegetated ditches...
- Several studies have shown that these have a potential to provide habitat for biodiversity
- **However, specialists have also pointed out the need to improve the design and management of rainwater systems to have a positive impacts on biodiversity.**
- Such as improving structural diversity, go to less or no management
- In addition, do not forget trees for rainwater management
- An American study has shown that the trees of New York City help to reduce runoff by 69 million cubic feet a year

River reopening in dense urban areas

France, Paris Region, city of Sarcelles

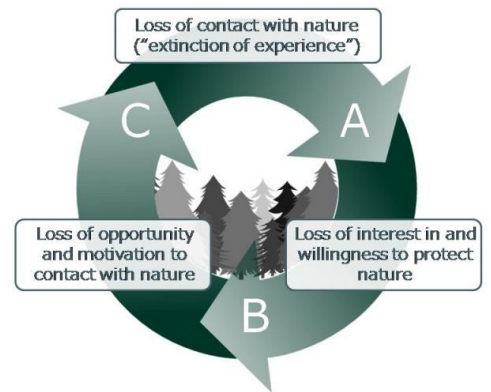


In 1992, the centre of Sarcelles found itself under 1.50 metres of water following heavy storms. Work began in 2014 with the aim of controlling flood risk and restoring nature in this urban area. Along a 165-metre stretch, a new riverbed was dug, the banks were reinforced and planted using ecological engineering techniques for part of the project. A post-project wildlife inventory was carried out in 2017/2018, laying the foundations for a long-term monitoring programme including fish, bats, moths, birds and plants. Water quality was also measured upstream and downstream in 2018. A few months after the project was completed, the first aquatic species (sticklebacks and aquatic macro-invertebrates) were observed.

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- Here we are in Sarcelles, a city near Paris (France), where a stream has been restored
- It was canalized into a concrete pipe, under a road
- As a result, in 1992 the center was under 1.50m under water
- The city with help of a structure specialized in hydraulic reopened and renatured the stream for biodiversity
- They used ecological engineering techniques, so the stream has been designed by and for biodiversity
- As a result, a post project monitoring shows that species come back quite quickly.
- They observed first fish species 1 month after the end of the stream restoration
- And today, flood no long occurs in the city

Extinction of nature experience



« The result of the loss of contact and subsequent alienation is the Extinction of Experience: an inexorable cycle of disconnection, apathy, and progressive depletion. Small, humble habitats, especially in urban settings, can be as important as big reserves in awakening biophilia. »

Nature Matrix: Reconnecting People and Nature
Robert Michael Pyle
April 2003

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- In our mineral cities, people don't have contact with nature
- Sociologists called these phenomenon "Extinction of nature experience"
- Many studies demonstrate that the loss of interaction with nature has negative impacts well being & health benefit and leads to a loss of interest in nature conservation :
 - Robert Michael Pyle, April 2003, Nature Matrix: Reconnecting People and Nature, DOI:10.1017/S0030605303000383
 - Prévot A.C., Cheval H., Raymond R. et Cosquer A. , 2018 — Routine experiences of nature in cities can increase personal commitment toward biodiversity conservation. Biological conservation ,<https://dx.doi.org/1016/j.biocon.2018.07.008>

Citizen sciences as a tool to reconnect people and nature

France, city of La Roche-sur-Yon, Involving citizens in participatory science



Ry la ville
La Roche-sur-Yon

*A lire : Ma ville nature : une année
d'animation autour des sciences
participatives*

© Ville de la Roche-sur-Yon

- So, it is urgent to reconnect people with nature
- Citizen sciences can be a solution
- Citizen sciences are research programmes that ask volunteers to collect biodiversity monitoring data to help scientists. At the same time, they propose to discover biodiversity
- Studies have shown that participatory science programmes increase participants' knowledge but also change their behavior.
- Studies show, for example, that participants adopt gardening practices that are more respectful of pollinators.
- This is why the city of La Roche-sur-Yon (France) has encouraged residents to participate in participatory science.
- They organised training days. In 2020, each month was dedicated to a particular programme: bats, birds, earthworms, pollinators, wild plants, newts and salamanders...
- For instance, here the link to Vigie Nature Ecole. It is a citizen science research program for schools (From kindergarten to high school) : <https://www.vigienature-ecole.fr/en>
- Vigie-Nature École offers scientific workshops to carry out with its students. They make it possible to simply carry out biodiversity monitoring. 10 protocols are available and make it possible to study a wide variety of groups.



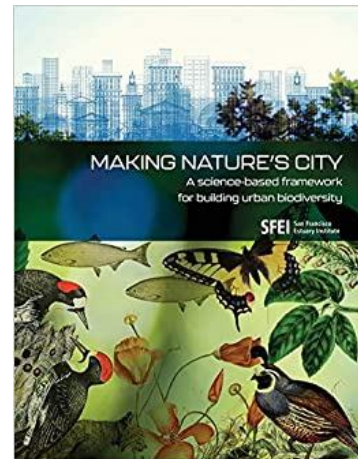
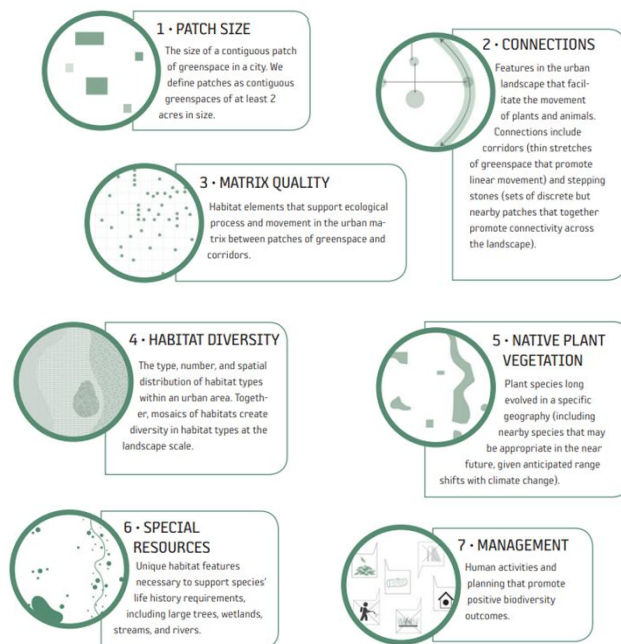
The importance of biodiversity to design NBS

Some researchers have warned policymakers and practitioners that NBS should be explicitly designed to provide measurable benefits for biodiversity (Seddon et al., 2021).



- **At the city level** : Nature-based solutions should be implemented regarding urban biodiversity needs
- **At the project level** : biodiversity is the support of ecosystem functioning, stability and resilience. This should be considered in NBS design and management.

At the city level: Elements that support urban biodiversity



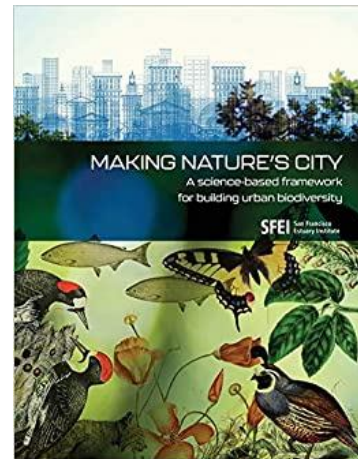
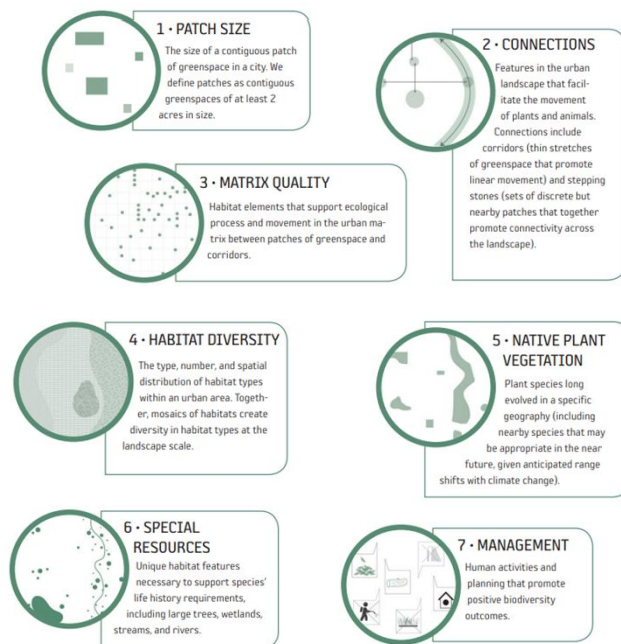
Spotswood, E., Grossinger, R., Hagerty, S., Bazo, M., Benjamin, M., Beller, E., ... & Askevold, R. (2019). *Making Nature's City: A Science-Based Framework for Building Urban Biodiversity*. San Francisco Estuary Institute. Publication, (947).

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Urban ecological science provides a powerful tool to guide cities towards more biodiversity-friendly design.

- ***Making Nature's City*** synthesized main results in urban ecology researches to develop a science-based approach for supporting nature in cities. They identify 7 key elements to maximize biodiversity in cities :
- **1. Patch size** : researchers identified patch size as one of two most important drivers of how much biodiversity is found in urban greenspaces (Beninde et al. 2015). This finding is consistent with research outside cities: one of the most predictable patterns in ecology is the relationship between the size of a patch and the number of species found within it.
- **2. Connections** : connectivity across the landscape is one of the most important elements driving biodiversity in cities. Landscapes with high connectivity may provide for higher numbers of species. The urban environment either supports or inhibits the movement of organisms across the landscape depending on the configuration of patches, corridors, and barriers. Landscapes with many connections and few barriers allow organisms to move freely to access resources, promoting gene flow and allowing organisms to access a variety of habitats during different life stages.
- **3. The capacity of patches of greenspace in cities to support biodiversity** depends in part on the habitat quality of the adjacent urban area. Patches of similar size amidst high-quality habitat in the urban matrix tend to support more species than those with surrounding high impervious cover and low habitat quality. Improving matrix quality can have a number of benefits for biodiversity. For example, high matrix quality around existing patches of greenspace can increase the effective size of a patch, allowing plants and animals additional space for life functions and movement.
- **4. Habitat diversity**. Landscapes with more habitat diversity can support higher numbers of species because they contain more total resources and niches for a diverse array of organisms to fill. Additionally, habitat diversity enables species to access resources in multiple types of habitats as they move across the landscape. Thus, it is both the diversity of habitats and their spatial arrangement that fosters biodiversity. [continues on next slide]

At the city level: Elements that support urban biodiversity



Spotswood, E., Grossinger, R., Hagerty, S., Bazo, M., Benjamin, M., Beller, E., ... & Askevold, R. (2019). *Making Nature's City: A Science-Based Framework for Building Urban Biodiversity*. San Francisco Estuary Institute. Publication, (947).

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[Continued from previous slide]

- **5. Native plant.** Native plant communities structure and define habitat types, and are critical for supporting a diversity of wildlife. Many studies have found greater biodiversity in urban greenspaces with greater abundance and richness of native plants (Goddard et al. 2010, Aronson et al. 2017, Threlfall et al. 2017). Native plants have complex and interdependent relationships with other organisms, developed through deep shared evolutionary histories. As a result, non-native plants are often poor substitutes for native plants, and exotic-dominated urban habitats tend to support less native wildlife.
- **6. Many species have specific habitat requirements,** and may be less successful in cities if specific requirements are not met.. In some cases, specialized requirements may only occur during certain times of year, or during certain life stages.
- **7. Management.** Improving the ways humans manipulate the landscape can help support more species in cities. From park maintenance to homeowner yard management to building design, a wide variety of human actions can influence biodiversity. Avoiding pruning trees and shrubs during bird and mammal breeding seasons can help reduce the impact of these activities on local wildlife (Hails and Kavanagh 2013). Retaining dead trees and branches can support cavity-nesting animals, and these resources are particularly important given their rarity in urban landscape.

A study has identified the **size of patches of greenspace** and **connectivity corridors** as the two most important predictors of biodiversity.

4,4ha

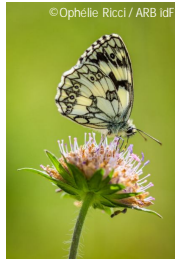
Minimal size to be considered as a patch for **urban utilizers**

53ha

Minimum size to be considered as a patch for **urban avoiders**



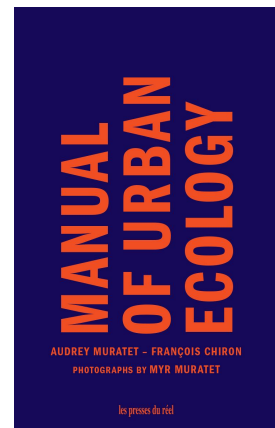
© Julien Birard



© Ophélie Ricci / ARB idF



© Ophélie Ricci / ARB idF



Manual of Urban Ecology
 Audrey Muratet & François Chiron
 2021

Beninde, J., Veith, M., & Hochkirch, A. (2015). Biodiversity in cities needs space: a meta-analysis of factors determining intra-urban biodiversity variation. *Ecology letters*, 18(6), 581-592.

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- Knowing that patch size matters in cities leads to a practical questions : what size patch is 'big enough' to support biodiversity?
- These questions have no firmly established scientific answers, but several studies have used the relationship between the size of a patch and the number of species it supports to identify thresholds below which species richness begins to rapidly decline.
- A recent summary of this work (Beninde et al. 2015) found the average patch size below which urban biodiversity rapidly declined was 4.4 ha (10.9 acres)
- But some species are highly area-sensitive or intolerant of urbanization and will only be found in large patches of continuous habitat where edges are minimized. Bendinde and co-authors (Beninde et al. 2015) found that the average patch size necessary to support **urban avoiders** species is 53.3 ha (132 acres)

At the neighborhood level : importance of the vegetation cover



Szulczewska et al. (2014) compared 18 neighborhoods (6 to 7ha) in Poland regarding the RBVA (Ratio of Biologically Vital Areas) and carried out inventories on plants and butterflies

45%
minimum

Vegetation cover for environmental stability

30%
minimum

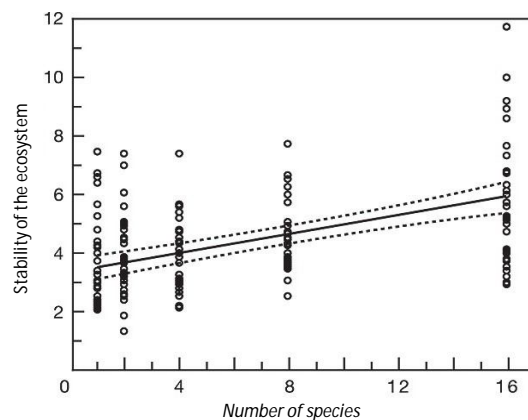
For a reduction of stress and anxiety

Cox et al. (2017) shows a threshold of 30% minimum vegetation cover to reduce mental health problems (stress, anxiety)

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- Several studies have highlighted the importance of plant cover and its positive effect on the number of species present in urban areas (*Aronson et al, 2014*).
- The difficulty lies in the definition of a threshold above which plant cover begins to offer optimum conditions for biodiversity.
- In 2017, an American study has shown that cases of stress and anxiety could be reduced by 17% or 25% if plant cover exceeded 20% or 30% respectively (*Cox et al, 2017*) within a 250-metre radius of where people live.
- In a Polish study (*Szulczewska et al, 2014*), researchers suggest that a minimum of 45% of spaces covered in vegetation (RBVA index) is necessary to provide environmental stability on the scale of the local area. Furthermore, a minimum of 45% plant cover or aquatic environments in residential neighbourhoods ensure adequate air cooling, permeability to rainwater and evapotranspiration during heatwaves.
- This is perhaps a figure for any urban project, the space should be shared, half for humans and half for nature!

At the project level : biodiversity improves the stability and productivity



Tilman, D., Reich, P. B., & Knops, J. M. (2006). Biodiversity and ecosystem stability in a decade-long grassland experiment. *Nature*, 441(7093), 629-632.

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Here are the results of a historical experiment conducted in the North American grassland.

- The experiment varies the number of species in the meadow and analyses the productivity and stability of the ecosystem
- Result: the higher the number of species, the higher the productivity.
- For the stability, researchers analysed the impact of the number of species on drought resistance (measured by the ratio between production in a drought situation and production without drought).
- Results: production in a drought situation is closer to production without drought the higher the specific diversity is.
- NBSs need to be designed to cope with climate change. So they must be designed by avoiding monospecific plantations and increasing the diversity of species plants or targeted.

At the project level : biodiverse ecosystems are more efficient to capture carbon



Cropland

Not biodiverse



70 TC/ha

Grassland



70 TC/ha

Forest

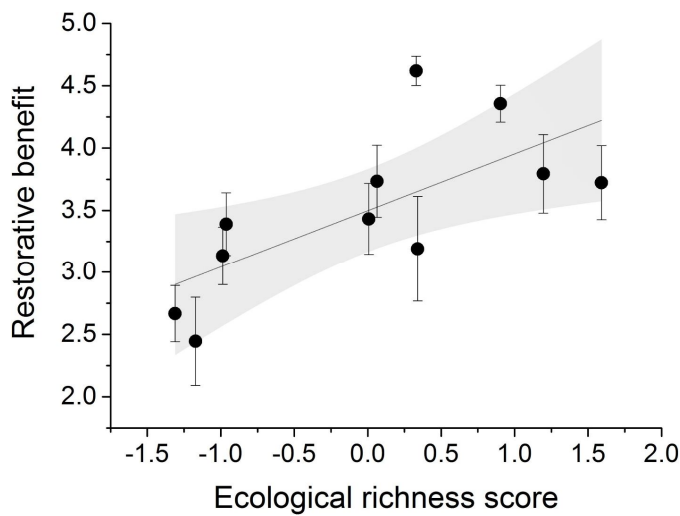
Biodiverse

Source: Arrouays, D., Feller, C., Jolivet, C., Saby, N., Andreux, F., Bernoux, M., & Cerri, C. (2003). Estimation de stocks de carbone organique des sols à différentes échelles d'espace et de temps. *Etude et gestion des sols*, 10(4), 347-355.

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- NBS are often chose targeted for climate adaptation, but we also know that they can contribute to capture CO₂
- However, different ecosystems do not have the same efficiency for capturing carbon, and this is important when it comes to the design of Nature-based solutions
- In this slide, a study from INRA France shows 3 types of ecosystems: a cropland, a grassland and a young forest. INRA has measured the carbon capture in the first 30cm of soils of these ecosystems
- It is interesting to see that cropland only stores half of the carbon compared to grasslands and forests, which are more biodiverse.
- There is one important thing : the more biodiverse the ecosystems are, the more carbon they can capture! That works also for urban ecosystems such as parks, green spaces, green roofs where we find the same results

Effect of biodiverse green spaces on well-being?



Many studies have demonstrated the positive effect of green spaces on health and well-being

However, the quality of these green spaces is not frequently addressed

This article shows a positive relationship between the ecological richness score (a composite score based on a combination of plant diversity, bird diversity, bee/butterfly diversity, and habitat number) and the mean restorative benefit of green spaces and parks.

Source : Houlden, V., Jani, A., & Hong, A. (2021). Is biodiversity of greenspace important for human health and wellbeing? A bibliometric analysis and systematic literature review. *Urban Forestry & Urban Greening*, 66, 127385.

55

- Many studies have demonstrated the positive effect of green spaces on health and well-being
- However, the quality of these green spaces is not frequently addressed
- **This article shows a positive relationship between the ecological richness score (a composite score based on a combination of plant diversity, bird diversity, bee/butterfly diversity, and habitat number) and the mean restorative benefit of green spaces and parks.**
- These findings suggest that urban planners should aim to enhance ecological diversity in urban green spaces, and so in NBS



Why depaving and renaturing cities ?

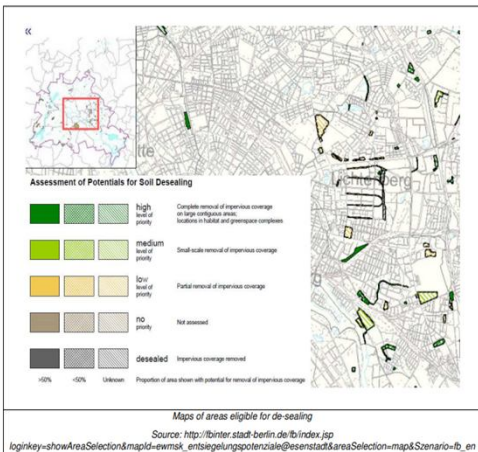


- Lack of spaces in dense cities to implement NBS
- Cities will have to achieve the “no net land take” policy
- Transforming mineral areas can provide maximum benefits for the people, for climate adaptation and for biodiversity
- Recovering soils is essential for developing nature-based solutions in cities (25% of biodiversity lives in soils).

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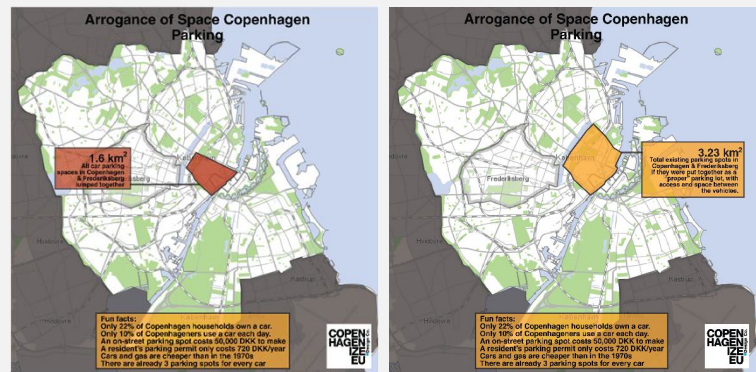
- Due to mineral areas : biodiversity is declining significantly in urban areas, the effects of climate change (runoff, flooding, urban heat islands, etc.) are intensifying and the health and wellbeing of city-dwellers are deteriorating.
- Renaturing makes it possible to adapt cities to climate change and to make them more permeable to wildlife by developing nature-based solutions.
- Our cities are full of areas that have been concreted or asphalted over and where nature could return and flourish.
- The European Union has defined an ambitious objective for the future concerning sustainable land use: to stop the process of Land take by 2050 : to achieve the aim of zero net land take by 2050. The implementation of the Net Zero Land Take goal requires a complex strategy that involves reducing urban sprawl by encouraging urban renewal and densification and using renaturing initiatives to restore land consumed by urban growth.
- Although soil is home to 25% of the world’s terrestrial biodiversity (*IPBES, 2019*), it is still poorly understood and has long been neglected and seen as a mere physical medium. The soil is, however, a fully-fledged component of biodiversity, providing a habitat for countless living organisms (microfauna, mesofauna and macrofauna) and acting as a medium for fundamental ecological processes such as biogeochemical cycles and the water cycle. NBS and renaturing cannot be implemented without taking into account the state of the soil and its ecological functionality.

Our cities are full of areas that have been needlessly concreted over



Berlin has created a database identifying potentially desealable zones + classifying each site according to the feasibility and priority of renaturing initiatives. In 2020, of the 179 sites identified, 31 have already been completely desealed and 14 partially desealed.

<https://www.berlin.de/umweltatlas/en/soil/removal-of-impervious-soil-coverage/continually-updated/summary/>



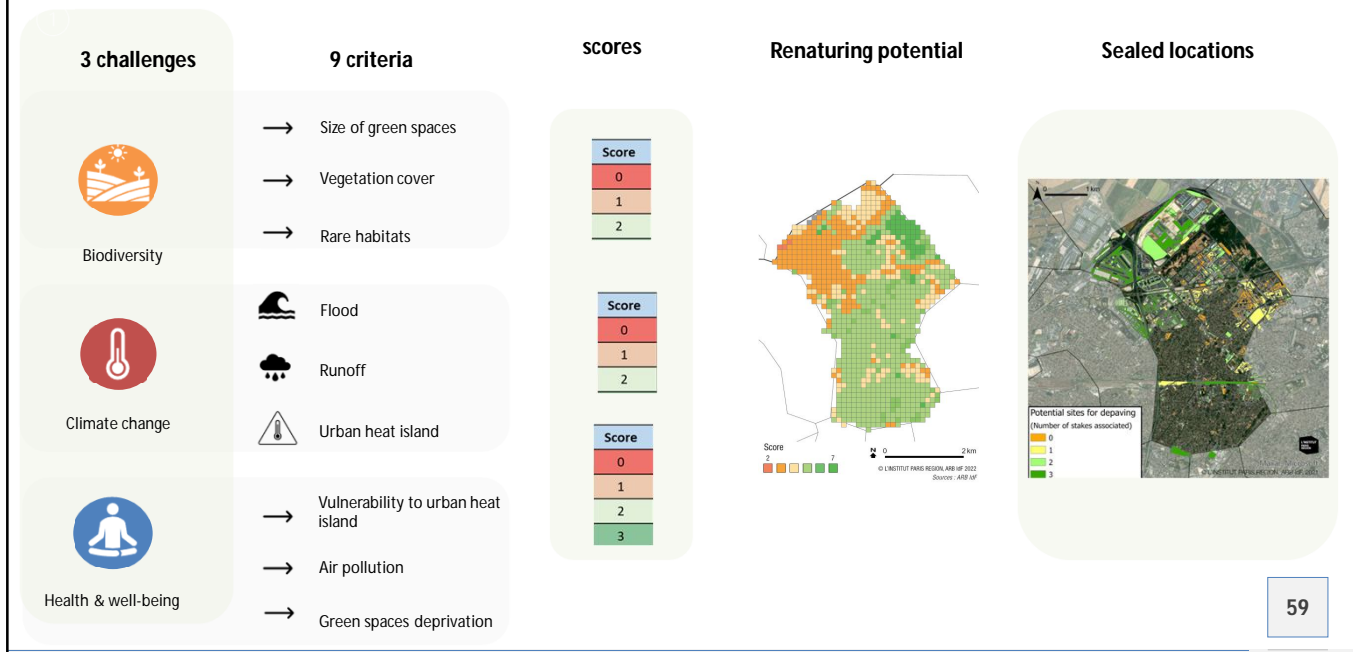
In Denmark, a cycling association has estimated how much space is taken up by parking spaces and car parks in Copenhagen. Placed side by side, parking spots would occupy a surface area of 1.6 square kilometres. If they were made into a single parking lot with spaces between the cars, it would cover 3.23 square kilometres.

<https://copenhagenize.com/2015/12/arrogance-of-parking-space-copenhagen.html>

In Berlin, the local government has rolled out a strategy to identify desealable sites as part of the federal Zero Net Land Take programme. This strategy, titled Potential for the Removal of Impervious Soil Coverage 2020, is similar to the Net Zero Land Take programme rolled out in France and offsets new land take by renaturing sealed areas. It is part of a Soil Quality Atlas developed as a decision-making tool for the city's planners. A survey carried out among council staff and the Forestry Department in Berlin has made it possible to create a database identifying potentially desealable zones. The study went further by classifying each site according to the feasibility and priority of renaturing initiatives. In 2020, of the 179 sites identified, 31 have already been completely desealed and 14 partially desealed.

In Denmark, a cycling association has estimated how much space is taken up by parking spaces and car parks in Copenhagen. Placed side by side, parking spots would occupy a surface area of 1.6 square kilometres. If they were made into a single parking lot with spaces between the cars, it would cover 3.23 square kilometres.

The « REGREEN » tool at a glance



Whether they are striving to achieve Net Zero Land Take goals or carrying out voluntary renaturing strategies, local authorities first need to identify areas with high renaturing potential. The REGREEN method is based on 3 key challenges that make it possible to locate these urban areas:

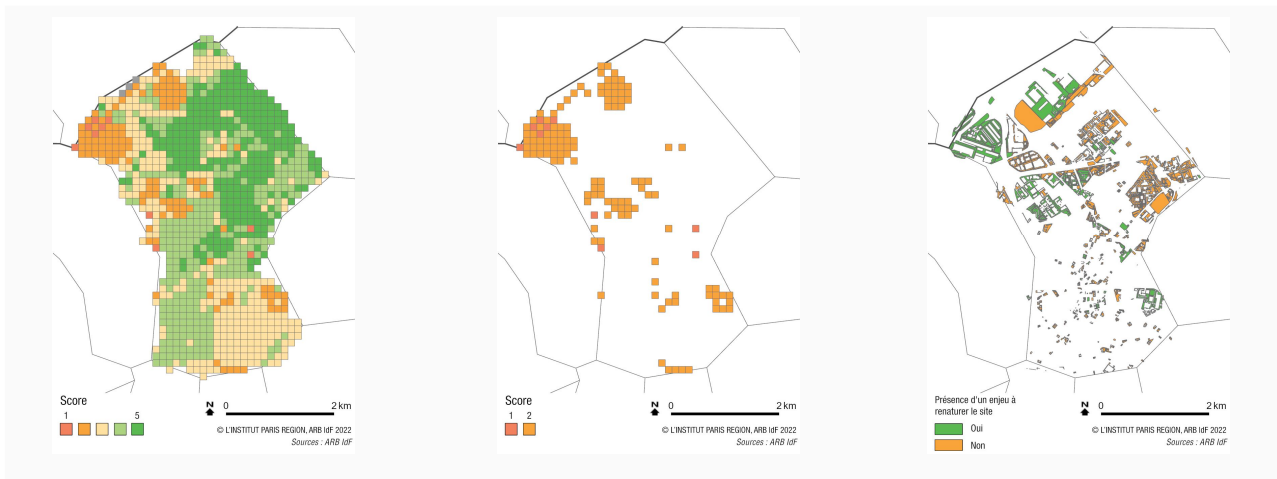
- **Restoring biodiversity** on targets areas that are deficient in terms of biodiversity, by studying the size of green spaces; the type of plant cover; the presence of rare habitats; and ecological connectivity.
- **Adapting to climate change** on targets areas exposed to climate risk: river flooding, runoff and urban heat islands.
- **Improving health and the living environment** on targets areas that are vulnerable because of lack of green spaces, air pollution and health problems relating to urban heat islands.

This methodology was carried out using a GIS approach (the flowcharts in Appendices 6-10 outline the analytical steps carried out). In order to carry out this analysis, the Paris Region was divided into 125 m x 125 m cells (cell size compatible with the data and studies of the Paris Region Institute). For each challenge (biodiversity, climate change and health), criteria were selected based on advice from experts and available data on the region.

The state of each cell is analysed and converted into a score. For example, a cell exposed more or less significantly to air pollution is given a score that reflects this. A score is thus attributed to each criterion, and then an overall score is given to each challenge. The attribution of overall scores corresponds to the sum total of individual scores for criteria, and the criteria are not weighted in any way.

Source: *REGREEN D3.2 Guidelines for depaving and re-greening strategy in cities*, Gwendoline Grandin (IPR), Gaëtane Deboeuf De Los Rios (IPR), Marc Barra (IPR), 28.2.2022. (<https://www.regreen-project.eu/wp-content/uploads/REGREEN-D3.2-Guidelines-for-depaving-and-re-greening-strategy-in-cities-2.pdf>)

Example in the city of Aulnay-sous-Bois



Maps of challenges



Priority zones for renaturation

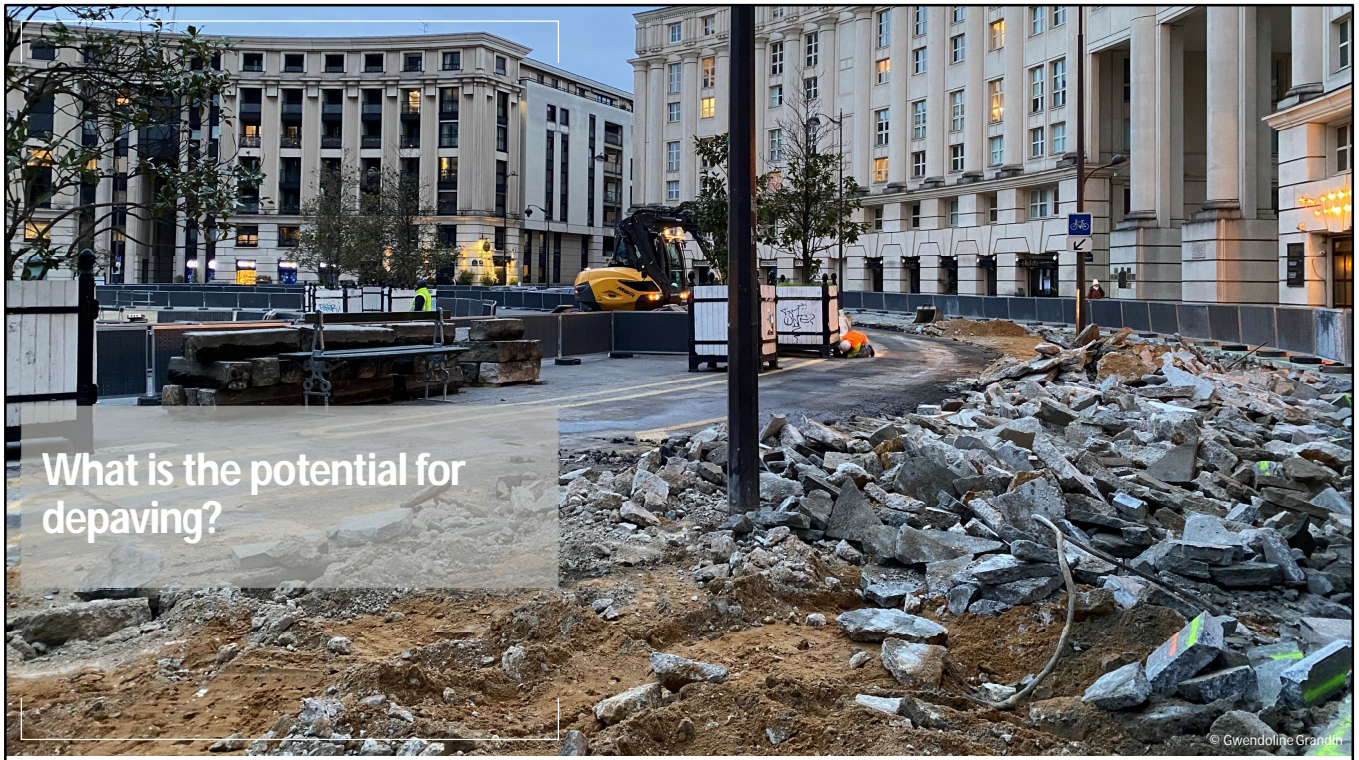


Identification of paved areas

60

Once the different criteria have been analysed and the overall score attributed, the cells for which the stakes are highest are identified. These are chosen according to their score (a low score reflects high stakes) and also according to how many of them there are (having too many cells might highlight an entire area and prevent prioritisation). This first step makes it possible to identify sectors where potential for renaturation is high, but it does not pinpoint sealed sites that could be renatured. To do this, potentially desealable / renaturable sites (school playgrounds, car parks, areas of waste ground, public squares, etc.) were listed based on the land use classification guidelines laid out in the *Mode d'Occupation du Sol* (MOS) published by the Paris Region Institute.

- Identification of desealable sites in high-stakes areas to improve health and/or the living environment in Aulnay-sous-Bois (Paris Region, département of Seine-Saint-Denis)
- MAP1 : overall map of risks to health and well being. MAP 2. Identification of areas with highest risks. MAP 3. Identification of potential sites for desealing to mitigate the risk.



Renaturing to increase the size of urban green habitats

Former Kodak factory : brownfield site to turned into an area of high ecological value.



62

Since the demolition and decontamination work at the Kodak factory in Sevrans ended, the 13- hectare site has been left untouched, allowing a range of species to reclaim it as their home. In 2015, based on the results of naturalist inventories, the town council decided to preserve the Kodak brownfield site without further intervention: its various environments, coupled with its size and location, make it into a refuge for urban biodiversity and provide an opportunity to reinforce the ecological continuity of a highly urbanised area. In 2017, CDC Biodiversité and Sevrans Town Council adopted a plan for the management of the site in the framework of the Nature 2050 programme. This document sets out objectives for maintaining existing habitats and recommends allowing spontaneous evolution in some areas. Among other things it recommends proceeding with the ecological restoration of several wetlands; allowing some areas of grassland to recover spontaneously; allowing 3 hectares of woodland to evolve freely; and setting up scientific monitoring programmes to assess the impact and relevance of each management approach.

Renaturing to reduce heat island effects

Tierce Forêt in Aubervilliers : Transforming a residents' car park into a recreational area designed to fight against UHI effect



Aubervilliers, Tierce Forêt ©Fieldwork Architecture



©Fieldwork Architecture

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The Tierce Forêt (“Third Forest”) project involved renaturing a car park and sealed concourse in front of a building in Aubervilliers. Its aim was to improve the living environment for residents of the building and to reduce the particularly high heat island effect on the site. The project grew from the idea of turning the car park in front of the building, a hostel for young workers, into a cross between a park and a square for the use of residents and employees. Soil analysis assessed the agronomic, physical, chemical and biological quality of the existing soil, sparking a conversation on how on-site restoration techniques could avoid the need to bring in topsoil from elsewhere.

The soil was restored using decompacted soil from the site, demolition materials and compost. To restore the water cycle, the sealed areas were replaced by permeable ground covering, including the heavy vehicle access road that had to be retained to allow the fire brigade to access the building. A rainwater reservoir was built using clay soil to avoid the use of in-ground concrete structures. To avoid the use of plastics, the new drains are made of terracotta. The reservoir is a useful source of water for the trees and extends the cooling effect in periods of drought. Where the planting strategy is concerned, solar irradiance measurements guided the choice of areas to be planted. The idea was to have a large canopy where the surrounding buildings provide the least shade. The species planted are local and selected for their ability to resist urban conditions. The roots were also mycorrhized to help the plants to absorb water and minerals from the soil. Last but not least, a meteorological station was installed to monitor the efficiency of the project. Early studies show an average temperature reduction of 2°C under the canopy, with perceived temperature said to be up to 6°C lower than before.

Renaturing projects by and for the local community

Wild garden on the site of a former car park in Aubervilliers : destroying a disused car park to transform it into a rock garden and improve the living environment



La Maladrerie is a housing estate built in the 1980s in Aubervilliers, a town in the *département* of Seine-Saint-Denis. The edge of the estate overlooked a car park that had been disused for several years. To improve the living environment, Wagon Landscaping and the artist Sylvie Da Costa, who lives in the estate, commissioned by the Aubervilliers Town Council Housing Office, worked for 5 days to create the garden. First the Council broke up the surface of the car park, leaving the rubble in place to create a 1,600 sq.m. “rock garden” that is a cross between an area of waste ground and a botanical garden. Soil was brought in and 150 species of perennials, shrubs and young trees were planted to kick-start a process of recolonisation.

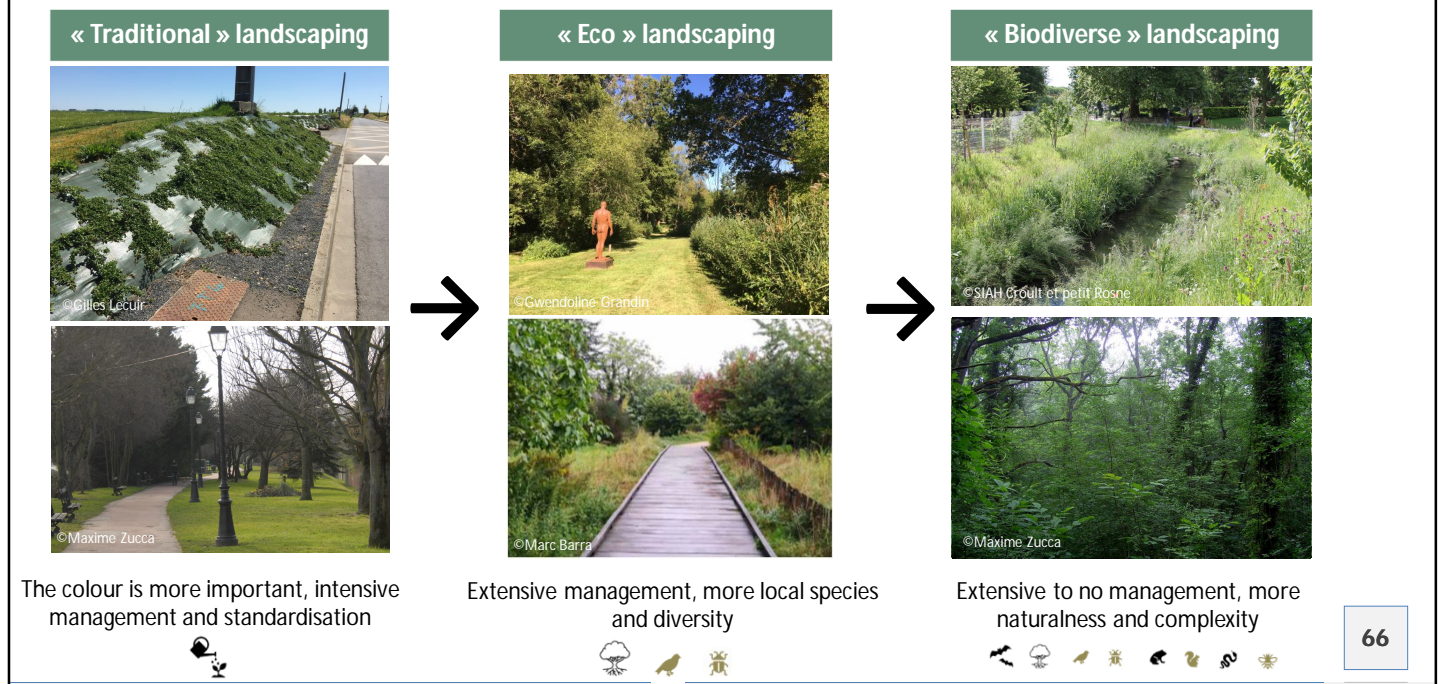
A total of 2,000 plants were introduced, chosen for their ability to adapt to uneven ground and requiring little maintenance. The Jardin des Joyeux is maintained as little as possible to preserve its rough, rocky appearance with asphalt peeking through the vegetation. Five years after the preparatory work, much of the broken asphalt has been overgrown. Wagon Landscaping managed the entire project, including the construction work. The garden requires minimum maintenance and no watering. Aubervilliers Council has organised several open days inviting residents to discover the project and the new on-going ecosystem.



FOCUS GROUP 2

**Green space design and
management : towards
more ecological quality**

From traditional to a biodiverse approach to landscape



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- In urban settings, nature is still often perceived as an approach to landscaping (*Pech, 2015*) whose main aim is to create a green decor that makes the city more attractive. In France, this kind of greening developed under the influence of formal landscaping whose legacy has been a highly controlled ornamental approach to nature focusing mainly on plants and ignoring other species as well as ecological functionality.
- We need to make a step forward not to consider that being green is being ecologic.
- We need to stop traditional landscaping that only consider nature as a green décor.
- The main objective of traditional landscaping is making cities nicer.
- If we want to improve ecological quality, we have to move towards Eco Landscaping: with extensive management, with practices that take into account soils and living organisms and basic needs of species.
- Eco landscaping is fully compatible/consistent with human uses.
- In addition, some areas have to be managed in a very extensive way or with no management at all. Here the objective is the recovery off more naturalness and complexity.
- But the transition from traditional landscaping to eco or biodiversity landscaping requires active collaboration between ecologists and landscapers.

Lanscaping or blandscaping?



- When traveling from city to city, we notice that globalization has influenced green space design, with the same landscape patterns and plants repeating. Some have even coined this phenomenon as **'blandscaping'** (Connop & Nash, 2018)

Blandscaping

- "Landscaping that uses the same designs, and often the same species, has become a 'best practice' model that has been shared and used across different urban regions nationally and globally"* (Connop, 2021).
- Such solutions are generally developed industrially so that they can be commercialised in the form of standardised or ready-to-use products.

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The growing interest in nature in urban environments goes hand in hand with a form of standardisation, for example beehives or insect hotels set up to the detriment of habitats for wild pollinators, "ready-to-use" systems for living roofs or planted façades disconnected from local requirements, and alluringly marketed urban micro-forests that do nothing to protect and regenerate brownfield sites and existing urban woodland.

This phenomenon, which certain researchers have dubbed "blandscaping" (Connop, 2018), involves solutions that use the same design approaches and often the same species, and are rolled out in different urban areas across the world. Such solutions are generally developed industrially so that they can be commercialised in the form of standardised or ready-to-use products. The living world depends above all on local realities, however.

Although commercial supply streams are necessary (e.g. for seeds, plants and materials), initiatives aimed at developing nature in cities and renaturing projects can only be conceived on an ad hoc basis, taking account of specific regional characteristics; they can hardly be developed industrially as this would inevitably lead to standardisation.

Applying the principles of ecological engineering makes it possible to avoid this pitfall by offering one-off solutions that are relevant to the local context, whose design focuses on the requirements, life patterns and intrinsic needs of species (size of habitat, connectivity, complexity of trophic networks), and which make use of local resources (reclaimed land, wild seeds collected nearby, species already present on site, etc.)

From landscape design...



Principles of Landscape Design

- Unity
- Balance
- Contrast and Harmony
- Color
- Transition
- Line
- Proportion
- Repetition

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- We need to make a step forward not to consider that being green is being ecologic
- Landscape design is playing with nature and controlling it / Urban ecology is about understanding nature and compose with it.
- Urban ecologists and landscape designers need to work together. Landscape design is the opposite of ecological landscape

... to landscape ecology principles



- Diversity of elements and habitats (varieties, species, functions)
- Size of green spaces
- Vegetation structure and composition
- Connectivity with other green spaces
- Management (mowing regimes, proportion of native plants, naturalness)

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- Whereas landscapes ecology principles are
 - Diversity of elements and habitats (varieties, species, functions)
 - Size of green spaces
 - Vegetation structure and composition
 - Connectivity with other green spaces
 - Management (mowing regimes, proportion of native plants, naturalness)
- Ecological design and management is about understanding nature and compose with it.
- Its primary aim is not to beautify but to maintain ecological functionalities by targeting relevant flora and fauna, by taking soil into account



Increase vegetation structure and composition (1/2)

More structure (different sized trees and bushes), and variety (diverse vegetation) can enhance habitat and function (Threlfall et al., 2016; Aronson et al., 2014) such as grass, herbs, mosses, shrubs, hedges, trees, etc



Threlfall et al. (2016) found 30–120% higher occupancy for bats, native birds, beetles and bugs with an increase in understory volume from 10 to 30%.



Le Roux et al. 2014 found that the only way to stop the decline of large old trees requires that:

- trees remain standing for at least 40% longer than currently tolerated lifespans;
- the number of seedlings established is increased by at least 60%;
- the formation of habitat structures provided by large old trees is accelerated by at least 30% (e.g. artificial structures) to compensate for short term deficits in habitat resources.

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- In relatively undisturbed areas, landscapes are usually characterized by mosaics of habitat types that follow physical and environmental gradients. This diversity is critical for supporting overall biodiversity.
- Landscapes with more habitat diversity can support higher numbers of species because they contain more total resources and niches for a diverse array of organisms to fill
- Additionally, habitat diversity enables species to access resources in multiple types of habitats as they move across the landscape
- Thus, it is both the diversity of habitats and their spatial arrangement that fosters biodiversity

GUIDELINES

- **Create habitat zones.** Habitat zones based on historical and physical information can be incorporated into a variety of urban greening actions across a variety of land use types, through actions like backyard gardening, street tree programs, landscaping, and park management.
- **Mimic the characteristics of particular habitat types.** Urban biodiversity interventions should seek to mimic, recreate, and preserve the spatial and vertical complexity that is characteristic of a particular habitat type.
- **Promote adjacency and connections across habitat types.** Creating connections between habitat types can be achieved through matrix improvements and vegetation management within greenspaces. For example, coordinated efforts in residential yards can create more coherent transitions between riparian and upland habitats.

Text source: <https://www.sfei.org/projects/making-natures-city>

Increase vegetation structure and composition (2/2)

More structure (different sized trees and bushes), and variety (diverse vegetation) can enhance habitat and function (Threlfall et al., 2016; Aronson et al., 2014) such as grass, herbs, mosses, shrubs, hedges, trees, etc



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- A study carried out in Melbourne shows that increasing the vegetation structure have positive effects for species. Having different height, strata of vegetation like herbaceous layer, shrub layer, bushes, sub-canopy, trees
- They found a 30-120% increase in occupancy of bats, native birds, beetles and bugs when the volume of understorey was increased from 10-30%
- Diversifying habitats is also a principle of ecological design or management. For instance, old trees are important for many species. They host more species than smaller trees because they offer more habitats due to their age like holes, dead wood, etc.
- Currently the number of old trees is collapsing in urban areas. To avoid this, an Australian study recommends:
 - conserving old trees and protecting them for longer than their currently accepted lifespan (they said 40% at least)
 - improving tree regeneration, so that old trees lost over time are replaced by younger trees
 - offsetting habitats provided by old trees with artificial habitat like nest boxes
 - OR with natural habitats like dead woods, fallen leaves, stone-heaps which are effective and suggested by several authors

Increase the proportion of native species

- Threlfall et al. (2016) found 10–140% higher occupancy across all native taxa with an increase in the proportion of native vegetation from 10 to 30%”
- A French initiative called “Vegetal Local” (native vegetation) allow municipalities to source native plants and seeds for green space design based on sub-climate divisions.



Several authors (Goddard et al. 2010, Schwartz et al. 2013, Le Roux et al. 2014, Beninde et al. 2015, Goddard et al. 2017) recall the importance of leaving dead wood (stumps, debris), litter on the ground and varying the vegetation layers



- Native plant communities' structure and define habitat types are critical for supporting a diversity of wildlife. Many studies have found greater biodiversity in urban greenspaces with greater abundance and richness of native plants
- Native plants have complex and interdependent relationships with other organisms, developed through deep shared evolutionary histories
- As a result, non-native plants are often poor substitutes for native plants, and exotic-dominated urban habitats tend to support less native wildlife

Guidelines

1. Plant and protect native plants to increase patch size, matrix quality, and connectivity
2. Plant a diversity of native plants to provide year-round resources.

Text source: <https://www.sfei.org/projects/making-natures-city>

- A study carried out in Melbourne shows that an increase of 10 to 30% in the proportion of native species, increase the occupancy of fauna from 10–140 %.
- In France there is an initiative called “Vegetal Local” (native vegetation) for helping cities to source native plants and seeds for green space design

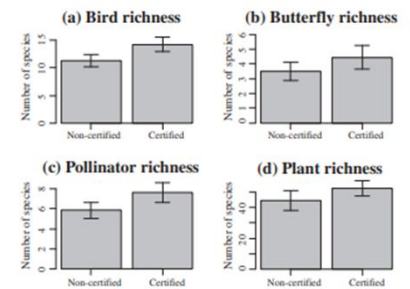
Vegetation management in existing green space

- Choosing to mow urban parkland less often, perhaps every few weeks, as opposed to once or twice a week, increases the number of pollinators (Connif, 2014).
- Many cities have taken reduced mowing schedules one step further by creating ‘no mow zones’ or ‘urban grow zones.’



Saint-lunaire has reduced mowing by 70% in the last 10 years, and mows once a year over 7cm.

<http://www.capitale-biodiversite.fr/sites/default/files/experience/documents/saint-lunaire-cfb2019.pdf>



Shwartz et al. (2013). Local and management variables outweigh landscape effects in enhancing the diversity of different taxa in a big metropolis. Biological Conservation, Elsevier

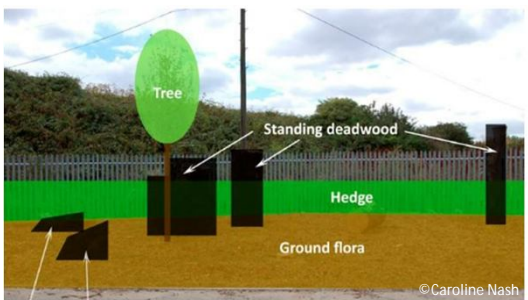
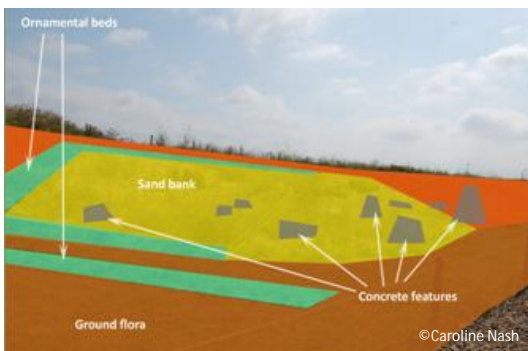
- Improving the ways humans manipulate the landscape can help support more species in cities.
- Among the many management actions that can benefit biodiversity, strategic stewardship of vegetation can improve its habitat value. Avoiding pruning trees and shrubs during bird and mammal breeding seasons can help reduce the impact of these activities on local wildlife
- Reducing the area covered by lawns and changing how they are managed can also help support biodiversity. Lawns require frequent upkeep, including mowing, irrigation, chemical fertilizers and pesticide addition, and are often composed of only a few non-native species. These management inputs tend to reduce biodiversity (Aronson et al. 2017) and are resource-intensive, with particularly acute costs in arid and semi-arid ecosystems. Replacing lawns with more drought-tolerant native vegetation can increase plant and animal biodiversity while reducing other impacts, such as water demand and pesticide use (Donofrio et al. 2009). Where lawns are desirable for recreation and social gathering, reducing the use of fertilizers and pesticides as well as the frequency of mowing will help reduce their negative impacts on biodiversity (McKinney 2006, Lerman et al. 2018).

Guidelines: Manage vegetation to mimic natural structure and form. Maintain the integrity of vegetation and leave organic materials on the ground, including logs and branches. In large open spaces where pedestrian traffic is minimal, maintain dead trees on the landscape. Reduce frequent mowing, and if possible, maintain clippings on the ground in areas where mowing is necessary. Consider nesting season and nest or den sites when designing vegetation management plans. Text source: <https://www.sfei.org/projects/making-natures-city>

- For example, reducing the frequency of mowing increase the number of pollinators.
- This is why the city of Saint-Lunaire, small city in the northwest France, has reduced mowing by 70% in the last 10 years, and mows some areas only once a year over 7cm.

Many cities have taken reduced mowing schedules one step further by creating ‘no mow zones’ or ‘urban grow zones.’

Brownfield-inspired green infrastructure



Nash, C.
2017. *Brownfield-inspired green infrastructure: a new approach to urban biodiversity conservation*. PhD Thesis University of East London ACE

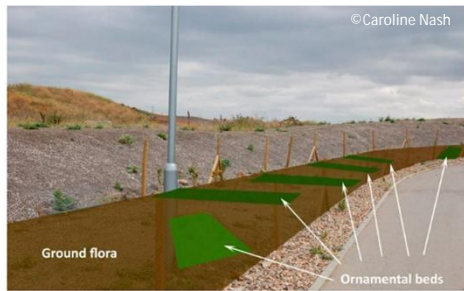
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Brownfield sites can support nationally and internationally important biodiversity that is being lost from the broader landscape. This research was undertaken in response to the need for targeted solutions to compensate for the loss of brownfield habitat mosaics to development. The research investigated innovative approaches to urban green infrastructure (UGI) design, based on ecomimicry of brownfield habitat mosaics. The aim being to support new developments in meeting sustainability goals in terms of no net loss of biodiversity.

The results validated the ecomimicry approach as a framework for UGI design, and the innovative measures investigated could make a valuable contribution to compensating for brownfield habitat loss in the region.

Source: Nash, C. 2017. *Brownfield-inspired green infrastructure: a new approach to urban biodiversity conservation*. PhD Thesis University of East London ACE <https://doi.org/10.15123/PUB.6678>
<https://repository.uel.ac.uk/item/84vy8>

Brownfield-inspired green infrastructure



a)



b)



c)



d)

(a) Diagram of key synusia within management unit BR05 and fixed-point photographs for (b) 2012, (c) 2013 and (d) 2014.

Nash, C.
2017. *Brownfield-inspired green infrastructure: a new approach to urban biodiversity conservation*. PhD Thesis University of East London ACE

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Surveys of plant and invertebrate communities were undertaken to explore community development, and evaluate the effectiveness of the brownfield mosaic ecomimicry approach to UGI design. Elements of the research were co-created with a developer to facilitate knowledge sharing. The experimental brownfield landscaping supported key conservation priority brownfield species and assemblages, and a much richer plant and invertebrate community than traditional landscaping.

Source: Nash, C. 2017. *Brownfield-inspired green infrastructure: a new approach to urban biodiversity conservation*. PhD Thesis University of East London ACE <https://doi.org/10.15123/PUB.6678>
<https://repository.uel.ac.uk/item/84vy8>

Target specific habitats for species :

The « Beetle Bump » / London



Aerial photo of the Beetle Bump habitat creation at the University of East London, Docklands Campus. Photo: ©UEL SRI



The Beetle Bump was designed to mimic the habitat features associated with the last site on which the streaked bombardier beetle (*Brachinus sclopeta*) was found.

It was created using a blend of low-nutrient, recycled aggregates sown with wildflowers typical of the region's brownfield sites (Connop 2012).

Surveys on the Bump in subsequent years revealed that a rich community including other conservation priority species were also utilising the habitat.

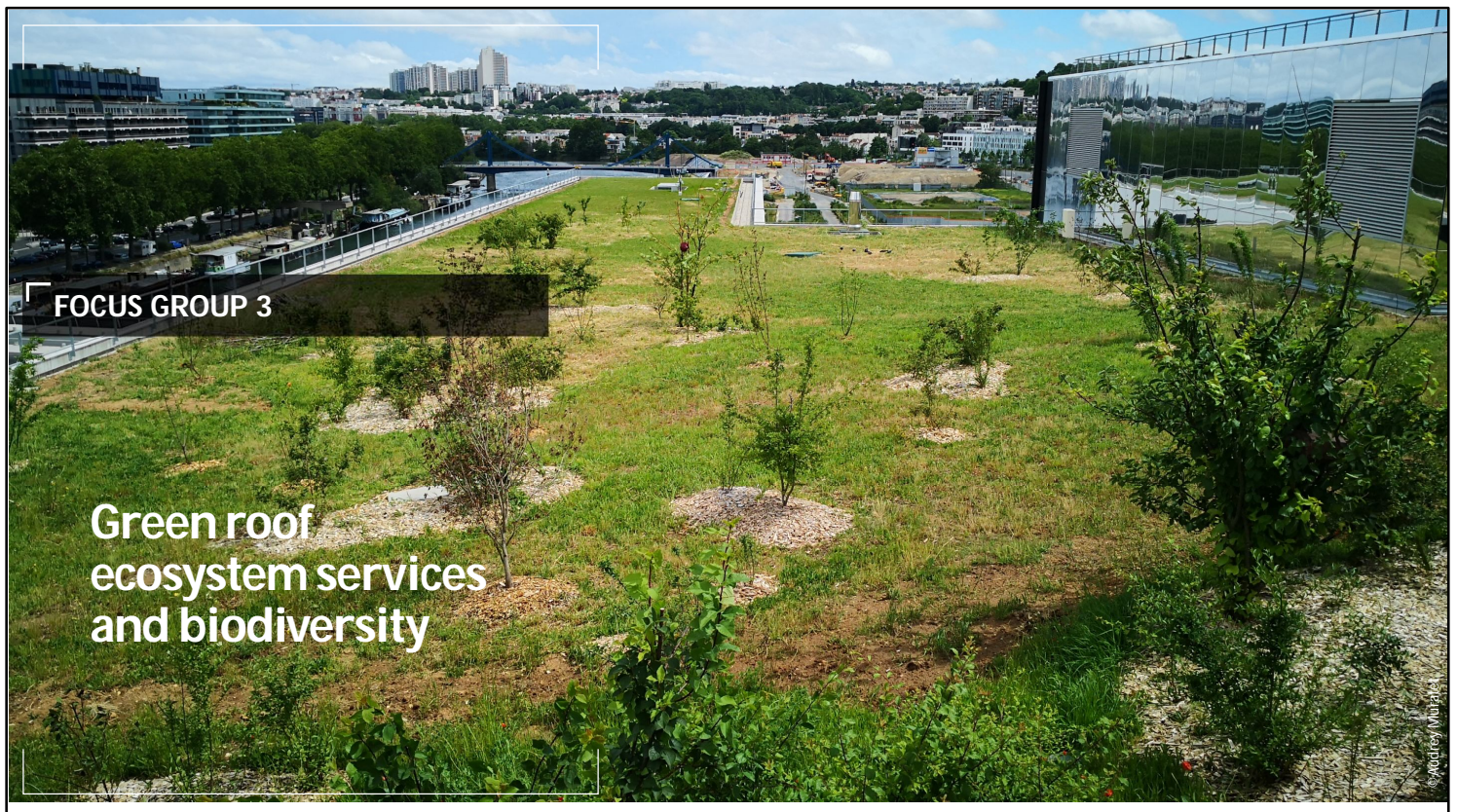
<https://www.thenatureofcities.com/2018/01/09/landscaping-erases-local-ecological-diversity/>

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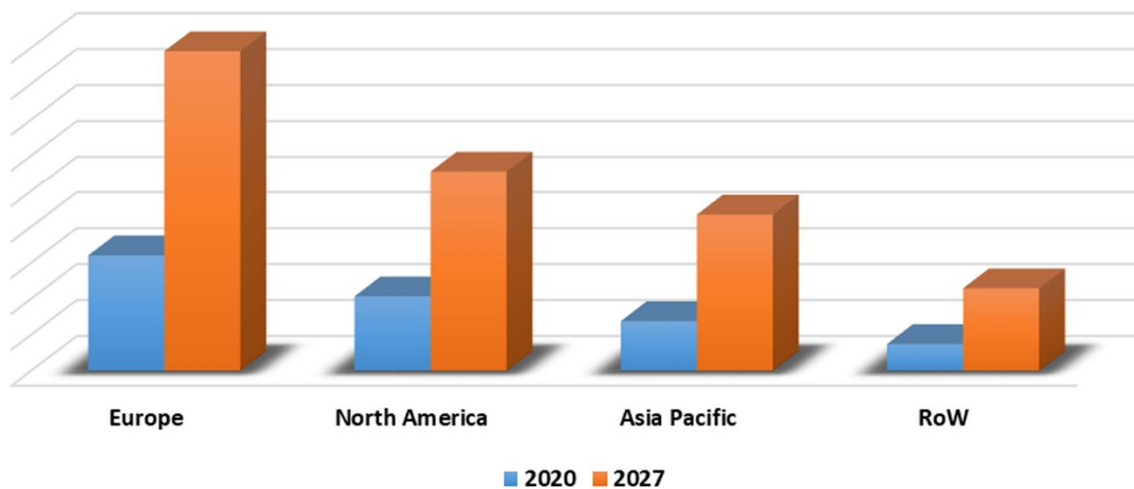
In the UK, the restoration of a habitat for the bombardier beetle (*Brachinus sclopeta*) is a remarkable example of renaturing focused on a single species. The beetle was associated with brownfield sites in London's Docklands in the East Thames corridor, and its last known habitat had to be destroyed to make way for development. In the framework of compensatory measures supported by Buglife (the Invertebrate Conservation Trust) and the University of East London, discussions led to the creation of the Beetle Bump, a renaturing project that mimics the characteristics of a brownfield site and reproduces the beetle's habitat. The operation involved bringing in a mixture of recycled aggregates poor in nutrients and sowing wild flowers typical of brownfield sites in the region (Connop *et al*, 2018). The bombardier beetles rescued from the construction site were moved to the Beetle Bump. Inventories over the ensuing years have demonstrated the quality of the habitat for the beetles and also for other species. This type of approach to renaturing could usefully improve landscaping practices in urban areas by bringing ecologists and landscape designers together.

KEY TAKEAWAYS

- It is possible to restore habitats targeting a single species or community of species. In this case, it is advisable to enlist the help of naturalist or ecologist organisations.
- Renaturing only makes sense if the restored environments are long-lasting. To ensure that they are, local authorities have a range of tools at their disposal, from land purchase to regulatory protection via their planning protocols.



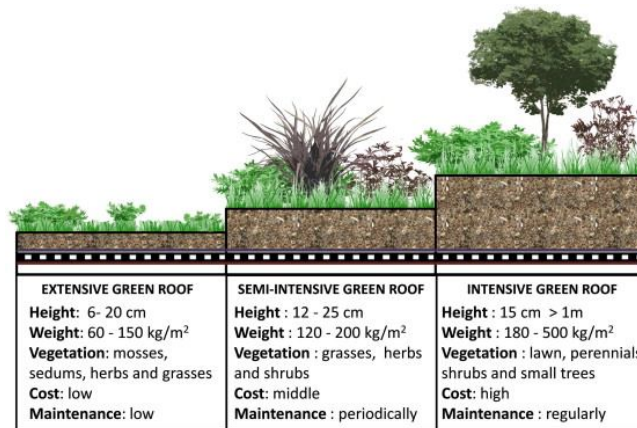
GLOBAL GREEN ROOF MARKET, BY GEOGRAPHY, 2020-2027(USD MILLION)



Global Green Roof Market Size By Product (Extensive and Intensive), By Application (Residential, Commercial, and Industrial), By Geographic Scope And Forecast. Report ID: 116127 | Published Date: Apr 2023 | No. of Pages: 202 | Base Year for Estimate: 2022

<https://www.verifiedmarketresearch.com/product/green-roof-market/>

- Green roofs have a long history, and their existence goes back thousands of years, especially in Scandinavia
- In the 1970s-80s, growing concerns raised by the degradation of the environment and the rapid disappearance of green spaces in cities sparked renewed interest in green roofs as an ecological solution in Northern Europe”
- According to the CSTB (Centre Scientifique et Technique du Bâtiment), the market for green roofs grew significantly in the 1980s in Germany, where almost 40 % of towns and cities offer financial incentives for their development.



Summary of green roof types based on the International Green Roof Association (IGRA) classification (IGRA, 2008)

- The market for green roofs is mainly occupied by roof sealing specialists, whose practices have gradually evolved.
- The growing popularity of planted buildings has accelerated the industrialisation of an entire sector, be it for waterproofing and drainage solutions, protective membranes and geotextiles, substrates, or plants and plant care (watering, fertilisation, etc.)
- The profession distinguishes three categories of green roofs: extensive, semi-extensive and intensive, determined by the depth of the substrate and the type of management, irrigation and plant strata associated with it.
- Other typologies have since been proposed, based in particular on the predominant plant stratum. In France and Europe, most green roofs are "extensive", in other words the depth of their substrate is no greater than 15 cm (it is generally between 5 and 8 cm) and their production is most often standardised (using pre-grown trays or rolls).
- The latter have become popular because they are lightweight, easy to install, inexpensive and low-maintenance.
- The prevalence of "ready-to-use" extensive green roofs has been criticised by landscape designers and ecologists alike, who saw this standardisation as leading to a lack of coherence with respect to the local context, an erosion of expertise (which was nonetheless highly diversified in this area) and an insufficient use of ecological skills (in botany, urban ecology and soil ecology) required in the framework of any urban nature policy

<https://guarinicenter.org/wp-content/uploads/2019/03/A-Review-of-Green-Roof-Laws-Policies.pdf>

TABLE: GREEN ROOF LAWS & POLICIES

CITY	LAW / POLICY TITLE	YEAR ENACTED	OPERATIVE PROVISION
Green Roof Mandates			
Basel, Switzerland	Building and Construction Law ⁴	2002	Green roofs required on all new and renovated flat roofs.
Copenhagen, Denmark	Green Roof Policy ⁵	2010	Requires green roofs on all new buildings with roof slopes of less than 30 degrees.
France (nationwide)	Biodiversity Act and Green Roof Statement ⁶	2015	Developers must build either green roofs or solar panels on all new commercial buildings.
Munich, Germany	Green Roof Ordinance ⁷	1997	Requires green roofs on all flat roofs larger than 100 square meters.
Portland, OR	Ecoroof Requirement ⁸	2018	Requires green roofs to cover 100 percent of the roofs on new buildings with a net building area of 20,000 square feet or more, excluding rooftop parking lots and several equipment and green alternatives (which can cover up to 40 percent of the roof).
San Francisco, CA	Better Roofs Ordinance ⁹	2017	Green roofs, solar, or a combination of both must comprise between 15 and 30 percent of the roof space on most new construction projects. San Francisco was the first city in the nation to mandate solar and green roofs on new buildings.
Tokyo, Japan	Green Roof Law ¹⁰	2001	Green roofs are required on new buildings with a flat roof area of at least 1,000 square meters.
Toronto, Canada	Green Roof Bylaw ¹¹	2009	Applies to new development or additions greater than 2,000 m ² gross floor area. Requires the installation of green roofs on new commercial, institutional, and multifamily residential developments. The size of green roof required ranges from 20 to 60 percent of the available roofs space, depending on the size of the building.



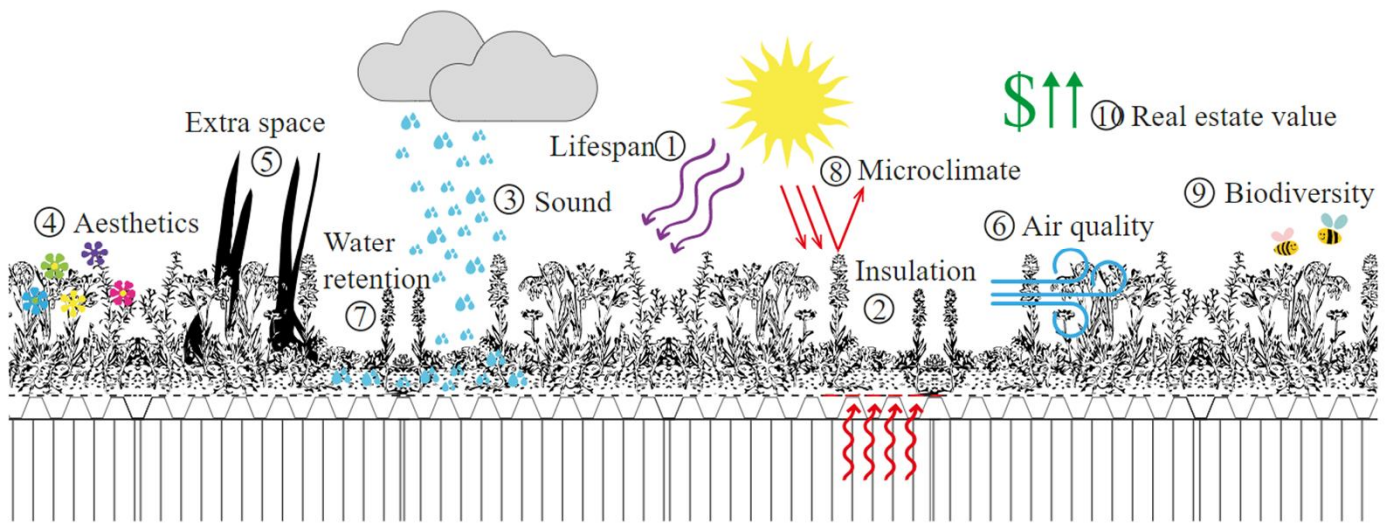
A Review of Green Roof Laws and Policies

Cities around the world have adopted diverse policies to promote green roofs in recent years. Several cities, including Toronto, San Francisco, and Copenhagen, have passed laws mandating green roof installations when constructing new buildings, or when renovating an existing buildings. Other cities, including Washington, DC, provide rebates or tax credits for green roof installation projects. Still others, including Austin and Portland, have amended their zoning laws to grant density bonuses or other zoning incentives to developers who pursue green roof projects. Finally, several cities provide reductions to stormwater fees to those who install green roofs.

This table is a synthesis of green roof laws and policies from across the word

Zürich, Switzerland	Green Roof Program ¹²	1991	All new or renovated buildings with flat roofs that are not used as roof terraces must have green roofs.
Sustainability Mandates			
Chicago, IL	Sustainable Development Policy ¹³	2004	Requires development projects that are receiving financial assistance or special approvals to reach a certain number of points, which are granted based on the use of specific sustainable strategies, including green roofs.
Denver, CO	Green Buildings Ordinance ¹⁴	2018	Requires new buildings 25,000 square feet or larger to have reflective, light-colored covering on the roof or portions of the roof, and must also do one of the following: install a green roof or solar panels; achieve LEED gold; purchase renewable energy; or pay a per-square-foot fee. A green roof ordinance was initially passed in 2017, but was altered in 2018 due to difficulties with the green roof mandate.
Seattle, WA	Seattle Green Factor ¹⁵	2006	Score-based code requirement that "increases the amount and improves the quality of landscaping in new development." Developments in specified zoning districts must achieve a certain score from credits based on various green landscaping options, including green roofs.
Rebates, Tax Abatements, & Refunds			
Hamburg, Germany	Green Roof Strategy ¹⁶	--	Building owners who install green roofs can receive subsidies covering up to 60 percent of the installation costs. This financial support (up to €3 million in total) is available until the end of 2019 through the Hamburg Ministry for Environment and Energy.
New York, NY	Green Roof and Solar Tax Abatement Program ¹⁷	2008	The city and state provided a tax credit of \$5.23 per square foot, up to \$100,000, but stopped accepting applications on March 15, 2018.

Advantages of green roof



©Constructing architect <https://www.constructingarchitect.com/10-reasons-to-have-green-roofs/>

- Green roofs are often seen :
 - as a way of making the urban fabric more permeable to wildlife and introducing natural spaces into areas where there are none.
 - as a way of providing ecosystem services like water retention, cooling, improve air quality, etc.
- But some research projects qualify all these services usually attributed to green roofs and whatever their design
- In his 2014 thesis, Frédéric Madre at the French National Museum of Natural History showed that there are different types of planting that are not equivalent in terms of biodiversity.
- In 2017, Yann Dusza at IEES-Paris became interested in ecosystem services associated with green roofs. He set out to understand the design parameters that influence major functions (the carbon, nitrogen and water cycle and pollination). His work shows that soil type and depth, plant species and plant diversity affect these ecosystem functions.



© Marc Barra | ARB idF



© Marc Barra | ARB idF

Some planting systems decay and can leave traces behind. Avoiding the use of plastics is more essential than ever in the design of green roofs

- Qualifying and quantifying the services provided by green roofs according to their design is all the more important as some roofs are composed of more artificial than natural elements.
- Still today, the market for green roofs all too often uses industrial processes, with planting systems combined with an array of synthetic components such as watering systems, fertilisers, plastic trays, non-biodegradable geotextiles, etc.
- These choices can affect the carbon footprint and the overall ecological footprint of green roofs.
- Because of the industrialisation of design methods, uncertainties remain regarding their ability to respond to a range of environmental challenges.



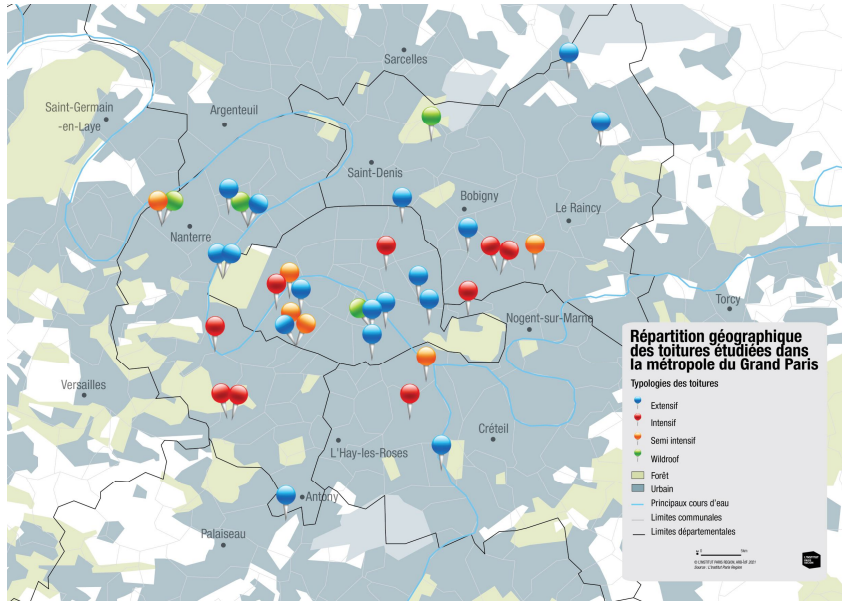
How can we improve the quality of green roofs in design and management ?

Between 2017 and 2019, the Agence Régionale de la Biodiversité (arbo Îdf) and its partners studied 36 green roofs in the Paris Region in order to assess the benefits of these new urban ecosystems. Biodiversity, rainwater retention and cooling are examples of the ecosystem services provided by the main types of green roofs assessed.

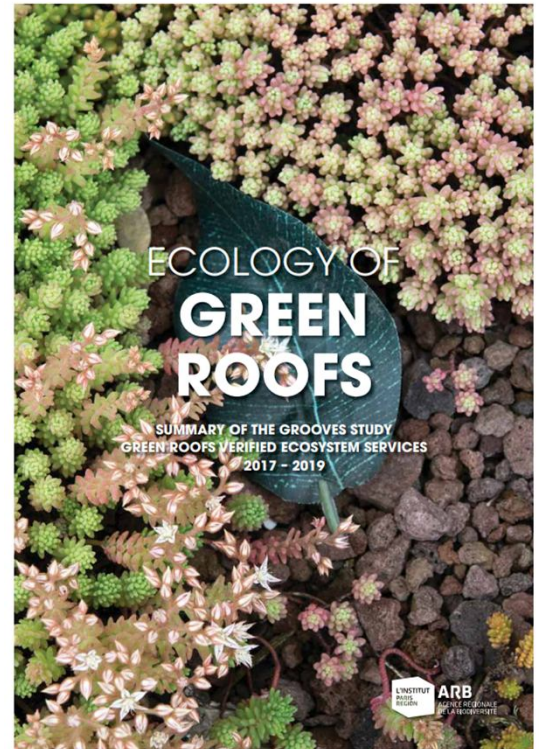
The GROOVES study (Green ROOfs Verified Ecosystem Services) selected 36 roofs in Paris and its inner suburbs. Professionals recognise three categories of green roofs, mainly depending on the depth of the soil : the study focuses on 18 extensive roofs (0 – 15 cm soil depth), 6 semi-intensive roofs (15 - 30 cm) and 8 intensive roofs (over 30 cm). There are also 4 “wildroofs”, a fourth type that denotes non-planted roofs on which plants grow spontaneously

- In total, about 400 plant species were observed on the 36 rooftops studied.
- Among the most frequently observed species are sedums, which are often used on green roofs. Rare species were also recorded, such as the yellow serradella (*Ornithopus compressus*) and the orange bird's foot (*Ornithopus pinnatus*). These observations confirm the role played by green roofs in providing habitat for varied, and sometimes rare, plants in urban areas.

36 roofs studied on the perimeter of Paris between 2017 and 2019



M. Barra, H. Johan (coord)., Écologie des toitures végétalisées. Synthèse de l'étude GROOVES (Green roofs verified ecosystem services). 2021, 92p.



Objectives of the GROOVES study

What are the benefits on biodiversity and some ecosystem services?

What are the differences between the design modes?

What are the differences with ground spaces for biodiversity?

What recommendations for designers and managers?

Between May and July over a period of three years, naturalists and ecologists carried out a range of different assessment protocols for biodiversity and ecosystem services :

- Vascular plants (plants with stems, leaves and roots)
- Vascular plants (plants with stems, leaves and roots)
- Invertebrates (insects, spiders, molluscs, etc.):
- Pollinators
- Soil
- Water retention
- Cooling

Green roofs design

Biodiverse & Wildlife



Source: <https://www.greenroofguide.co.uk/>

It is advisable to vary substrate depth on a roof to create different conditions for living organisms. By the same token, the diversification of plant strata (moss layer, herbaceous layer, shrubs or even trees) is a sign of quality

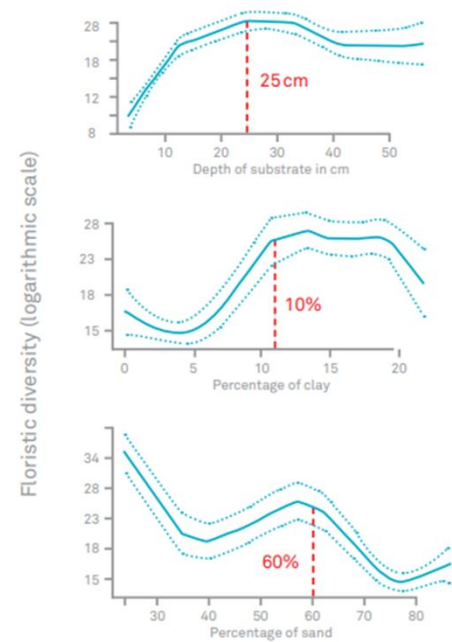


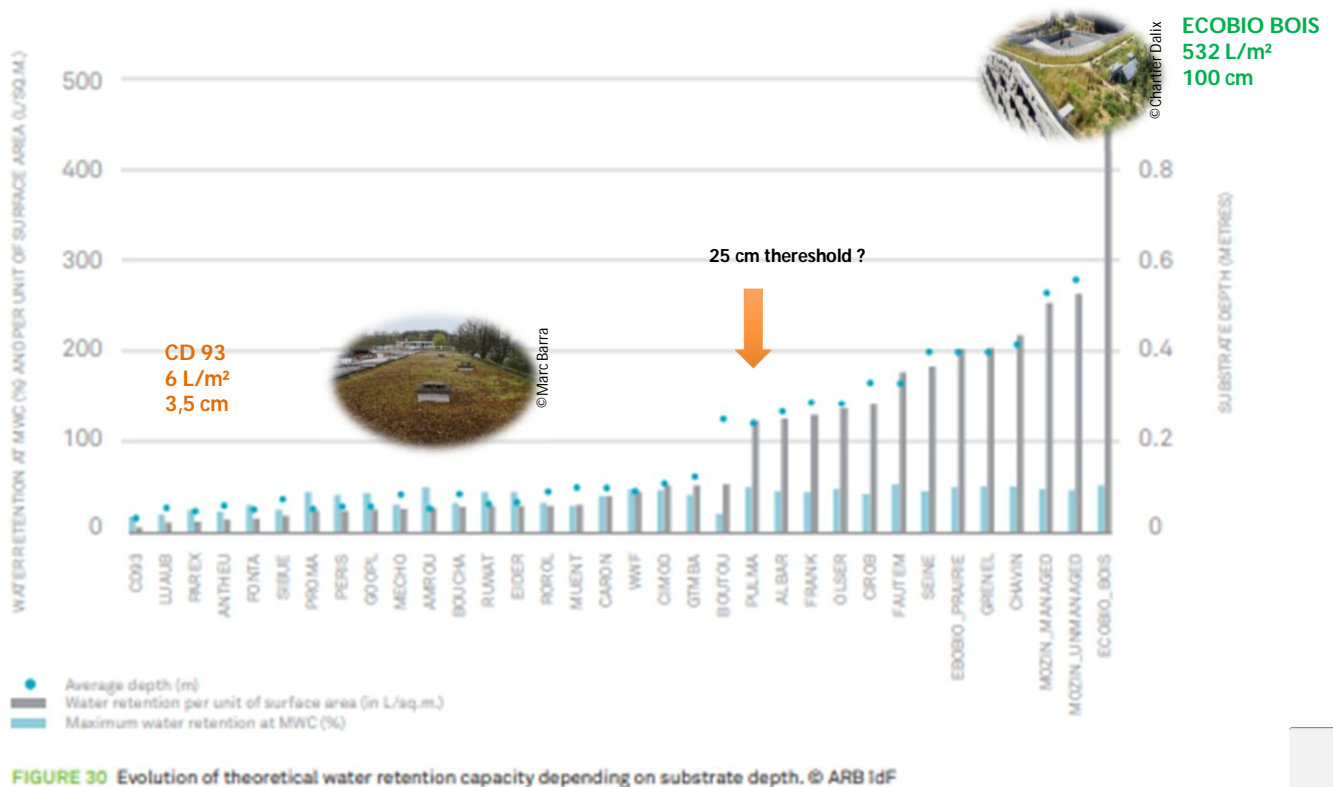
FIGURE 10 Substrate depth and clay/sand content influence floristic diversity. © Audrey Muratet | ARB idF

Results – figure 10.

- Substrate depth is the factor that best explains the richness of flora. We observe that flora does not increase beyond a depth of 25cm.
- The composition of the substrate also plays an important role in the establishment of diverse flora: analysis shows that maximum floristic diversity occurs in soil that contains around 10 % clay and 60 % sand.

Other results

- One of the unexpected outcomes of the study was that it highlighted a negative relationship between the surface area of the roof and the diversity of spontaneous plants. This may be due to the fact that the conditions on large roofs can be more extreme in terms of heat and drought as they are less well protected by buildings or natural features and more exposed to the wind.
- The height of the building is correlated with the number of spontaneous plants. The effect is positive up to 10 meters (about 3 floors). Above this height, the amount of flora no longer increases. These observations appear to indicate that height is a determining factor but need to be confirmed by more detailed analysis.
- The effects of the landscape have also been assessed. These mainly include how the ground surrounding the building is occupied (by other built structures, green spaces, etc.). However, the results we obtained do not show that the environment has any influence on rooftop flora. Design factors thus seem to play a decisive role in how successfully different plants establish themselves on roofs.
- It is advisable to vary substrate depth on a roof to create different conditions for living organisms. By the same token, the diversification of plant strata (moss layer, herbaceous layer, shrubs or even trees) is a sign of quality



- Laboratory analysis of substrates has given a better understanding of the water storage potential of rooftops.
- Maximum Water Retention or MWR (at Maximum Water Capacity or MWC) is obtained in the laboratory by mass differential. MWR is the difference between the mass after drying and the mass before saturation.
- Several variables can affect the water retention capacity of green roofs. Some depend directly on the substrate (its depth, composition, grain size or texture), while other factors such as plant biomass can also affect water storage potential.
- The results obtained in the laboratory show that “agricultural soil” and “mixed” substrates can store more water than “mineral” substrates owing to their composition (percentage of clay, organic matter content, etc.) and structure (grain size, porosity, etc.).
- The relationship between substrate depth and maximum water retention capacity allows us to estimate the theoretical volume of water that different green roofs are able to retain. We observe significant variations between the least absorbent roof (CD 93 with 6 L/sq.m., Mineral substrate, 3.5 cm deep) and the most absorbent (Ecobio_Bois with 532 L/sq.m., agricultural soil substrate, 100 cm deep).
- For effective water retention, it is essential to take substrate depth into account at the design stage.
- The values calculated indicate, in theory, that there is a threshold at 25 cm beyond which the retention capacity of green roofs increases significantly. These values are theoretical and presuppose that the roofs are totally dry before rainfall. But it could guide the design of green roofs (substrate depth) if we want to optimize water retention



The school of Science and biodiversity in Boulogne Billancourt

The school of Science and biodiversity in Boulogne Billancourt has the greatest water retention capacity, above 500L per square meter. No runoff pipes are necessary underground, the totality of rainwater is managed by the greenroof.

<https://www.archdaily.com/585862/primary-school-for-sciences-and-biodiversity-chartier-dalix-architectes>



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Original brown roof – Laban Dance Centre, London - ©<https://livingroofs.org/>

The extensive roofs, which have an essentially mineral substrate and/or which are shallow, host a lower diversity of flora than intensive or semi-intensive roofs.

Although less diverse, their composition is unique in cities, and they feature original combinations such as planted and spontaneous species that grow in dry, sandy grassland which may either be local or come from Mediterranean, continental, North American ecosystems.



- The extensive roofs, which have an essentially mineral substrate and/or which are shallow, host a lower diversity of flora than intensive or semi-intensive roofs.
- Although less diverse, their composition is unique in cities, and they feature original combinations such as planted and spontaneous species that grow in dry, sandy grassland which may either be local or come from Mediterranean, continental, North American ecosystems.

Native and local plants on green roofs



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Items can be placed on the roof to create extra habitats for species: piles of rocks, dead wood, a pond, etc.

- Items can be placed on the roof to create extra habitats for species: piles of rocks, dead wood, a pond, etc.
- For planted roofs, opt for local plant varieties from trusted suppliers (e.g. in France those participating in the "Végétal local®" programme). It is also possible to collect wild seeds from neighbouring environments.
- It is advisable to vary substrate depth on a roof to create different conditions for living organisms. By the same token, the diversification of plant strata (moss layer, herbaceous layer, shrubs or even trees) is a sign of quality
- Here it is a green roof created by *Philippe Peiger*. He has the great idea to transplant meadow clods on the roof for boosting colonization by local plants. The roof is in landscape harmony with the surrounding meadows

Green roof of the Aimé Césaire school in Nantes



The green roof of the Aimé Césaire school in Nantes has been designed using a biomimicry approach : the ecosystem of the roof is analogue to the dunes and litoral ecosystems found nearby.

Green roof of the Aimé Césaire school in Nantes

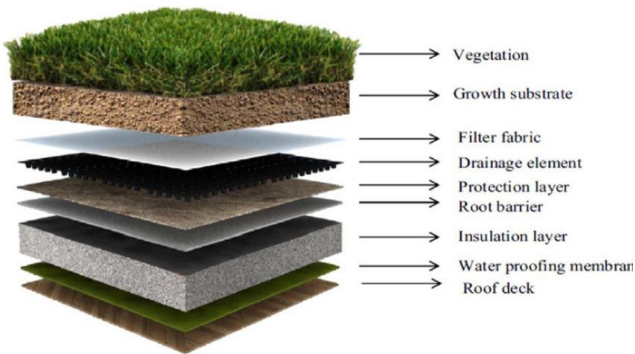


- 25 planted
- 36 spontaneous



- Although some native species have been planted, most of the plants covering the roof are spontaneous
- The dune zone is composed of: sandy soil with planting of grasses. The planting densities were important from the start in order to ensure an immediate plant atmosphere.
- The heathland is composed of: a poor clay substrate mixed with heather soil, stony areas, and wet depressions. Plantation densities are low. Plantations were supplemented with seedlings to allow natural colonization by other species. This area is a support for experimentation in order to observe the diversity of species and its evolution. The inventories carried out a few years later : 25 species of planted plants + 36 species of spontaneous
- <https://oppla.eu/casestudy/19519>

Can we reduce the foot print of green roofs ?



Le Trung, N., Khawaja, M., Beyranvand, E., Bucchini, D., Singh, A., & Alam, A. A. (2018)

To reduce the ecological footprint created by materials, it is necessary to adopt a low-tech approach at the design stage in order to limit the number of artificial components (geotextile membranes, plastic trays, etc.).



Plastic nets

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Membranes and geotextiles

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Pre-cultivated sedum mats

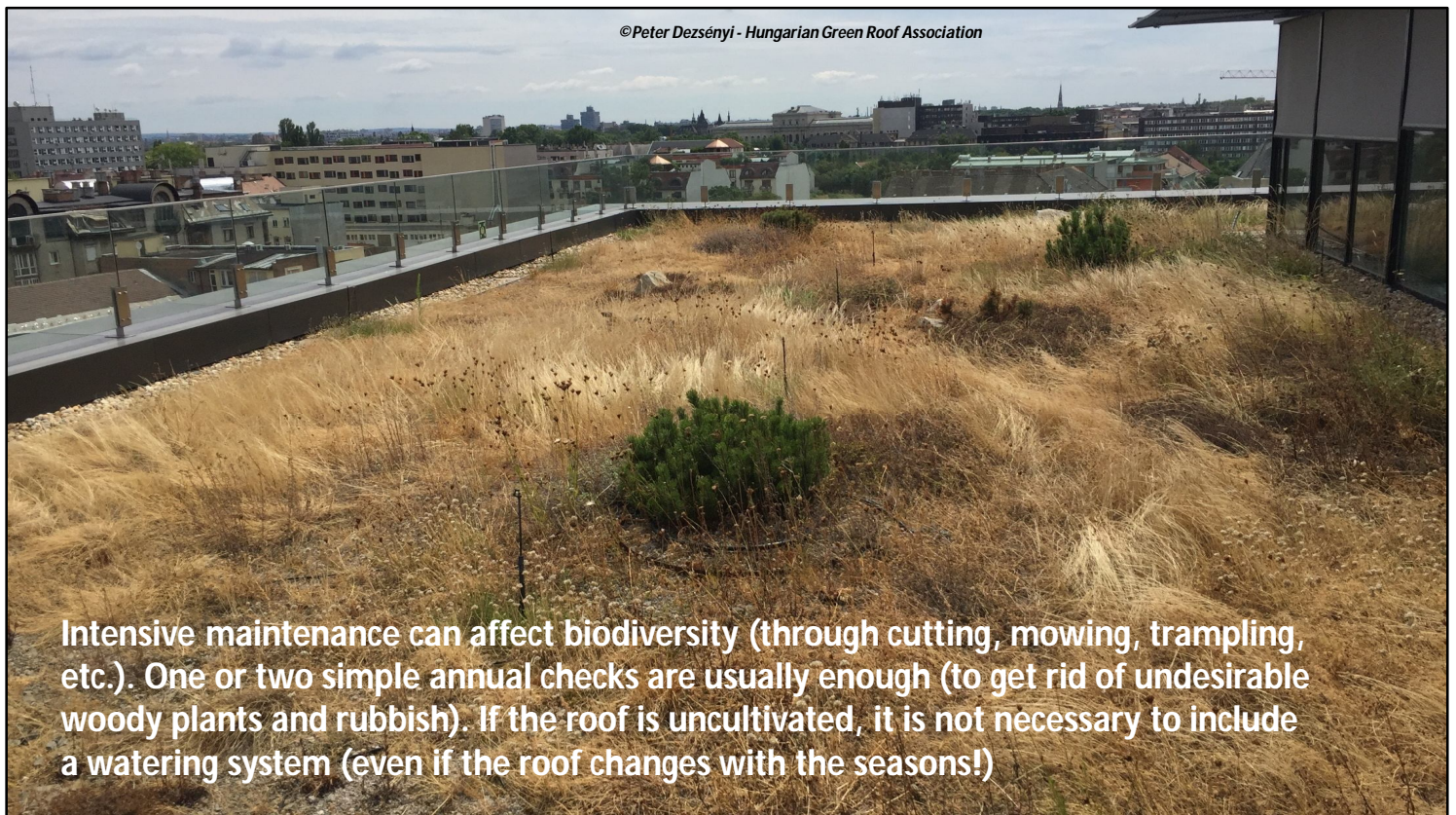
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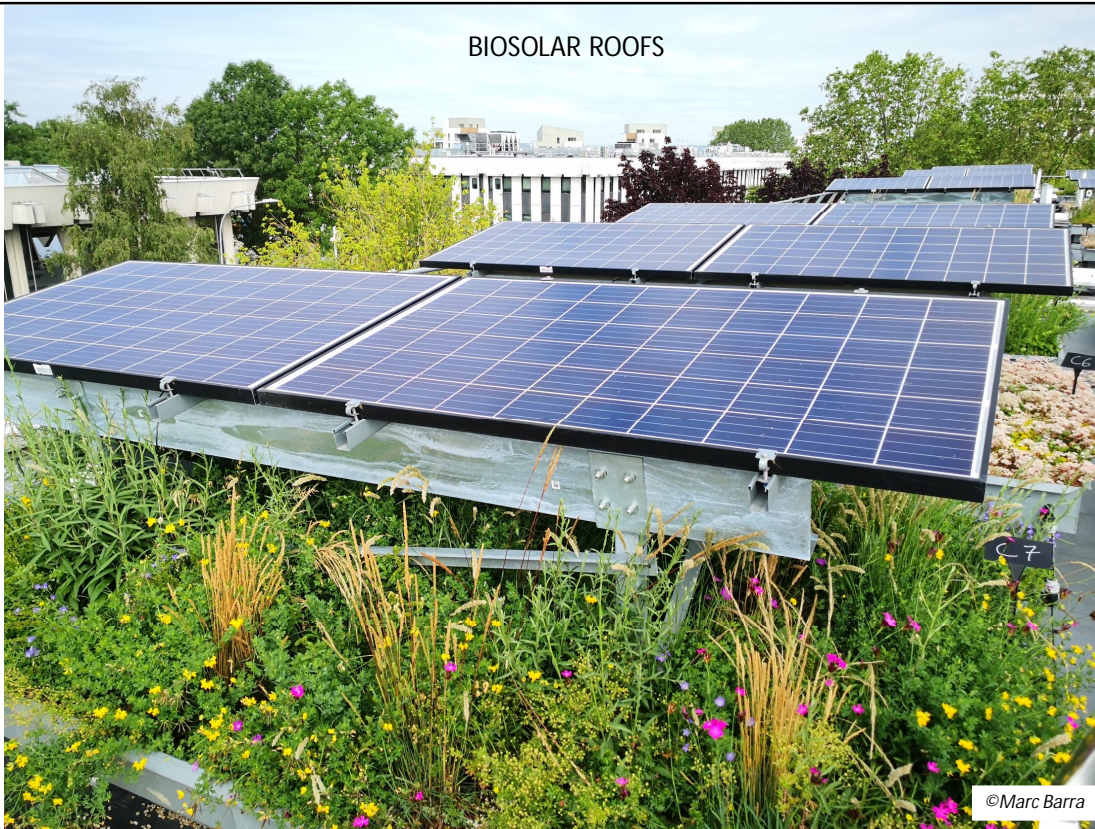
Non-biobased components

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- The aim of green roofs is to benefit the environment. Still today, the market for green roofs all too often uses industrial processes, with planting systems combined with an array of synthetic components such as watering systems, fertilisers, plastic trays, non-biodegradable geotextiles, etc. These choices can affect the carbon footprint—and the overall ecological footprint of green roofs.
- In the framework of the GROOVES study; it was recorded the components of the planting systems by direct observation. In addition to the roof sealing complex, which is essential to both the substrate and the plants, green roofs can contain up to four man-made elements. These are mainly plastic trays containing the plants or used as a drainage layer; non-biodegradable geotextiles, membranes or felt; plastic netting or coir matting; or built-in drip watering systems. If we take the sealing and drainage complex into account, this number can rise to 8 (steam shields; insulating layers; aluminium strips; root barriers).
- Among the 36 roofs studied in GROOVES, 13 had no man-made components, only substrate and plants, which confirms that it is possible to limit the use of potentially energy-guzzling materials that can leave traces on the roof (e.g. plastic debris left behind when the systems decay sometimes on very recent roofs). This aspect must not be neglected, especially as these artificial components add to the cost of green roofs. It may be necessary to carry out a carbon footprint assessment or a Life Cycle Assessment (LCA) of the planting systems



- As is the case for green spaces, the management of urban ecosystems is often associated with a particular organised vision of nature that has no ecological justification.
- Constant intervention is unnecessary; one or several visits per year to weed out woody plants is enough for the long-term maintenance of a roof.
- Over-intensive management may have a negative impact on floristic diversity and cause excessive soil compaction.
- Similarly, it is not necessary to water green roofs on a regular basis. Although certain roofs are chosen for aesthetic reasons, accepting the seasons and the changing colours and appearance of plants reflects a different way of looking at nature.
- Allowing vegetation to proliferate and fostering the development of multiple plant strata provide essential support to pollinators and other invertebrates.
- Moreover, a dense, well-developed herbaceous stratum will improve the roof's capacity for evapotranspiration and water retention. To provide pollinators and other invertebrates with a welcoming environment, creating micro-habitats (dead wood, stones, hollow stems, bare sandy substrate for wild bees, etc.) is a solution that can also increase the attractiveness of roofs provided it is combined with suitable vegetation.



Biosolar roofs are a combination of planted roof with solar panels. According to recent studies, the vegetation has a cooling effect on solar panels whereas solar panels create shady conditions for the vegetation (with an effect on plant diversification).

This project is a PhD experiment in the city of Rungis in France, held by the French office for biodiversity



Neuville-sur-Oise, 2017 - M. Barra



Paris 19e - M. Barra



Climbing plants are more rustic and less expensive, are to be preferred with artificial walls

Ottelé, M. et al. (2011) compared 4 façade greening systems, including climbing plants and modular green walls, on the basis of a life cycle analysis. The ecological footprint of the latter is 5 times larger.

Meral, A. et al. (2018) compared the costs of climbing plant systems with those of modular green walls. On average, the installation of climbing plants costs 34.87€ / m² while the modular walls cost 415.649€ / m²

- For walls, in most cases it is preferable (and often much less expensive) to prioritise the use of climbing plants, using and designing walls and facades as support structures for vegetation.
- Green artificial facades.
 - Their implementation has several technical drawbacks: some require multiple supports (metal cladding, integrated irrigation system, artificial substrate) and large quantities of resources (water, inputs, plant renewal)
 - They are less resilient. If the water system breaks, plants die very quickly
 - They are often composed with non native plants
- Climbing plants are easy to install, are more resilient. They are an ecological and economical alternative.