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# Novel Urban Ecosystems: Opportunities from and to Landscape Architecture

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**Abstract:** Novel assemblages of biotic, abiotic, and social components resulting from human-induced actions (e.g., climate change, land-use change, species movement) have been labeled as "Novel Ecosystems", or "Novel Urban Ecosystems" when emerging in urban contexts. This concept has been shifting perspectives among some scientists and making them question traditional values about human-nature interactions in a rapidly changing era dominated by anthropogenic actions (Anthropocene). Controversial dimensions surrounding the Novel Ecosystems and Novel Urban Ecosystems terms may be preventing the evolution and further research of these concepts. The environmental problems that our society will soon face support a search for innovative solutions and transdisciplinary efforts. For that reason, this discussion should not cease, rather should expand to other fields of knowledge that can contribute with pertinent insights and collaborations. This way, this short communication aims to reflect on the opportunities from Landscape Architecture to the discussion, research, and application of the novel ecosystems concepts in the real world, particularly in the urban landscape, and also reflect on the opportunities of this debate to the Landscape Architecture field. Ultimately, Landscape Architecture can contribute with innovative and creative perspectives, acceding valuable and advanced tools, facilitating dialogues between fields of knowledge, and bridging gaps between science, people, and nature.

**Keywords:** Anthropocene; concept; controversy; design; human-nature interactions; landscape; novel ecosystems; transdisciplinarity



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## 1. Introduction

Over the last decades a concept has emerged to describe unprecedented combinations (and interactions) of biotic, abiotic, and social components resulting from human-induced actions (e.g., climate change, land-use change, or species movements), but with a tendency to manifest novel qualities without, or in spite of, extensive human intervention [1–3]. "Novel Ecosystems" (NE) are challenging conventional conservation and restoration practices and raising controversial questions in the scientific community [4,5]. The debate around this concept aims mostly at defining appropriate management, restoration, and conservation targets in a rapidly changing era dominated by anthropogenic actions (i.e., the Anthropocene) [6]. In the urban context, the concept is being referred to as "Novel Urban Ecosystems" (NUE) and has gained a renewed relevance since ecological novelty is widespread in urban landscapes, where the impacts of human actions are more profound and prevalent [7–9].

Although some researchers recognize the usefulness of these concepts (NE and NUE) in the Anthropocene context without pre-established value judgments [4,10–13], others are

against them, raising numerous reservations and concerns about the emergence and propagation of these ecosystems [14–17]. The controversy involving NE and NUE irremediably influences researchers' and practitioners' perceptions about this subject and may prevent the concepts from being further applied or investigated at a more advanced level. For that reason, the debate around NE and NUE should continue and should even expand to include other disciplines across the natural and social sciences, arts, and humanities [4,18,19].

This short communication aims to reflect on the possible opportunities from Landscape Architecture to this debate, and, on the other hand, reflect on the opportunities of this exciting debate to the Landscape Architecture field, particularly in the urban context (NUE), where the connection with the discipline is most relevant. We argue that Landscape Architecture can contribute to the understanding and clarification of this concept mainly in urban contexts. The horticultural, ecological, and design knowledge and skills of the profession can support the investigation of these ecosystems in the real world and facilitate the integration of the NUE concept in the planning, design, and management of the urban landscape. Additionally, the NUE concept can also be relevant for the evolution of the discipline, especially by promoting a professional practice more grounded and focused on solving environmental problems emerging worldwide in the "new" age of the Anthropocene, and therefore able to keep up with current hot topics and innovation pathways.

To address these objectives, it is important, however, to explain and synthesize the most consistent and dominant controversial aspects of this concept by presenting the arguments both researchers' factions have used in the literature, namely resorting to published papers that have initiated an ongoing action-reaction discussion. This short communication is structured to address these objectives as follows:

- First, we present a background of the most controversial dimensions of the general NE concept, which in most cases can be extrapolated to the concept in the urban context (NUE) as well. We focus particularly on the concept's definition and terminology, pragmatism and utility, and concerns and misunderstandings;

- Then, we present arguments that support the opportunities from and to Landscape Architecture, briefly resorting to examples that demonstrate how the profession has already contributed to this subject.

## 2. Controversial Dimensions of the Novel Ecosystems Concept

Controversy arises mostly related to the general NE concept as it emerged first in the literature and the dissemination of these types of ecosystems in non-urban areas are considered more problematic to conservation and restoration efforts [14–17]. In urban areas, NUE are increasingly being assumed as already largely widespread [7,8,20] and occurring in different degrees of urban ecological novelty throughout urban green spaces [21,22]. Although NUE still needs clarification and further research, the concept appears to be gaining acceptance and increasing relevance among researchers and practitioners compared to the NE concept.

### *2.1. Definition and Terminology*

Even though it describes a not-so-novel phenomenon, the original and general concept of NE emerged in the scientific literature just over two decades ago [11,18,23] and was later applied to the urban context (NUE) [8,24]. The concept's acceptance in the literature has been quite problematic as several authors have attempted to define it differently, causing some authors to argue against the concept [1–3,25–27]. The opposing faction claims that the general NE concept is inaccurately defined, ambiguous, continuously mutating, and poorly developed as no quantitative criteria to characterize NE have yet been developed [14–17]. Still, advocates of NE tend to remind readers that the development of an ecological concept is an ongoing process that requires the support of empirical evidence [28] and that debate is a crucial component in the development of other concepts and frameworks [29]. Although these criticisms have been pointed out to the concept, in general, the same necessarily applies to the concept in the urban context. In that sense, recent studies have started

to address these criticisms, namely seeking a common language [18,30], reviewing the concept in both non-urban and urban contexts [9], quantifying levels of ecological novelty in cities [21,22], and assessing the role of ecological novelty in the conservation of urban biodiversity [31,32].

There are also reservations concerning the terminology used. The term "novel" was adopted in 1997 [33] and later largely accepted after Hobbs and colleagues' seminal paper [1]. According to some authors [14–16], this term suggests a positive connotation and may send a conflicting message. Nevertheless, the term is merely designating a new "novel" kind of ecosystem that emerged through human-induced changes without using a pejorative label [34].

### *2.2. Pragmatism and Utility*

Another often-debated topic refers to the actual utility of NE and NUE. In that sense, some researchers defend that the general NE concept has little pragmatic value as it does not provide new insights or breakthrough approaches on how to deal with highly transformed ecosystems [14]. Nevertheless, not only are the NE and NUE concepts pertinent to raise awareness about emergent and urgent topics (e.g., global urbanization, climate changes, and species introductions), but they may have an active role in the search for answers and solutions [18].

NE and NUE support conservation aims [5,8,31,32], even though a clear policy context is still lacking [35]. Importantly, NE and NUE help to prioritize restoration, planning, and management actions across different contexts (urban, non-urban, and in-betweens), taking into consideration the available resources [28]. Restoration to nontangible pristine conditions seems an unrealistic endeavor for many contexts and conditions, not just because of the associated efforts and costs but also due to the complex ecological relationships emerging in these ecosystems, especially in urban settings. The concepts allow practitioners to justify alternative goals when the restoration is not practical or desirable and helps to reserve restoration efforts for worthy locations where restoration to historical conditions may still be feasible [28,34]. Even though these ecosystems emerge from intentional and unintentional human influence, they do not require human management to provide ecological functions [3] and essential ecosystem services (e.g., degraded land reclamation, watershed protection, carbon sequestration/storage, habitat for rare and native species, stormwater management, climate mitigation, and recreational opportunities) that are comparable to other types of ecosystems [28,31,32,36].

### *2.3. Concerns and Misunderstandings*

Researchers who are against the concepts have also pointed out a wide list of concerns. They fear that accepting NE and NUE will lead to irreversible biodiversity losses, uncontrolled species invasions, and unpredictable climate change effects [5]. Simultaneously, they are concerned that decision-makers will eventually reduce investments in nature conservation or that land managers will renounce restoration even when it is feasible [16,34]. Much of these concerns are related to the fact that NE and NUE have theoretically crossed ecological thresholds to the point that returning them to a previous ecological state is highly challenging. Critics argue that crossing a threshold does not imply irreversibility [15], and barriers to restoration based on socioeconomic and political limitations should not be confused with ecological thresholds [16,17]. Nevertheless, NE and NUE are not described as irreversible, rather as difficult to reverse or reversible only with significant resources and efforts [1,25,34]. Likewise, even if barriers to restoration are frequently socioeconomic (resources, institutional will, policy settings, and other social aspects) rather than ecological, these factors are rarely separable in practice [28,37].

The NE and NUE concepts question traditional conservation and restoration approaches. Researchers against these concepts argue that these ecosystems "lower the bar" and will legitimize society's tendency to ignore negative environmental impacts in the long term [15]. Nevertheless, Hobbs [38] questions the assumption that these ecosystems can

always be viewed as "degraded" and argues that some altered systems are simply different from what existed previously and not necessarily damaged or in need of restoration. Even though critics of the concept agree that anthropogenic changes are accelerating, they defend that attempts to control non-native species based on currently perceived impacts rather than the origin of the species are a risky strategy since knowledge about biological invasion is still limited [39]. Valuing NE and NUE do not necessarily entail devaluing other types of ecosystems [5]. And acknowledging their existence does not imply that managers cease to control invasive species and that traditional conservation and restoration practices are completely replaced from now on [4,40]. The NE and NUE concepts will expand options and allow discussion of solutions based on priorities and the likelihood of success of different interventions [4,28,29,41,42]. This discussion should be stimulated once many of these concerns are founded on misunderstandings and, in some cases, prejudice [4].

## 3. Opportunities from and to Landscape Architecture

The challenges raised by NE and NUE are already triggering the reformulation of methodologies and paradigms in ecology [7] and highlighting the need for cooperation between fields of knowledge to solve the complex issues society will increasingly face [43,44]. When debating new theories and concepts that can help respond to emerging environmental problems, it is imperative to welcome a myriad of perspectives and to combine efforts from different disciplines [45]. A collaborative learning process between scientists and practitioners is critical to producing effective knowledge and common language on multiple fronts, contexts, and scales [18,30,45–48].

Landscape Architecture is, in its essence, a collaborative and interdisciplinary profession that is able to engage various areas of knowledge (sciences, arts, and humanities) to address and understand its object of study [49]. As such, this field is equipped with a much-needed holistic and flexible perspective upon the various layers that form a landscape: its history, memory, and evolution, as well as its ecological, cultural, and socio-economic characteristics [49]. Additionally, the field of Landscape Architecture has been building relevant knowledge and vast experience about the urban landscape for many years, including the dynamics of native and nonnative plants assemblages, from both theoretical and practical points of view [49–51]. Many Landscape Architects have substantial knowledge and skills with the physical characteristics, processes, and dynamics of the urban environment including grading and drainage, soils and structures, vegetation analysis, design and management, and the human experience and value of the environment. This holistic perspective and acquired knowledge are valuable when studying complex systems such as NUE [19], namely contributing to the resolution of the previously identified controversial dimensions of the concept.

NUEs are socio-ecological systems emerging in profoundly constructed landscapes, where mankind and nature collide in highly complex ways that are difficult to fully understand. Even though the human agency is inextricably linked to NUE genesis, it is still crucial to understand how people perceive these ecosystems. Will people accept or value new forms of urban nature? Otherwise, the integration and accommodation of NUE in urban environments will not be easy nor viable [48,52]. The successful implementation of new ideas, concepts, and solutions requires that people's perspectives are considered, even promoting their engagement and participation at different stages of the process [50]. As cities offer limited space for urban nature and ecological novelty is largely widespread in urban settlements, it is arguably increasingly urgent to promote more contact and access to NUE. In the context of the Anthropocene, NUE can be relevant sources of benefits to the population's well-being and quality of life while also supporting fundamental ecological processes to local fauna and flora [44,52,53].

Nevertheless, urban dwellers may not be prepared yet to fully embrace NUE, which implies that these ecosystems must be reshaped according to societal expectations while also striving to meet critical ecological and economic goals that are often misaligned [47,48,54–56]. It may be helpful to educate people and explain what NUE represents, their potential op-

portunities, and the role of society in their creation. But mostly, it will be critical to consider people's interests, values, and preferences in this discussion, such as what they like or dislike, what they need, and the benefits they will mostly value in urban green spaces (e.g., beauty, biodiversity, well-being, health, or comfort) [52,54,57]. Understanding people's social values, preferences, and attitudes towards NUE can inform and support their design, planning, or management, thereby increasing their general acceptance and successful integration in political agendas [35,52,58,59]. To this end, studies using well-established approaches from the social sciences, such as questionnaires often assembled with photographs or photo-manipulations [60], are being implemented to understand urban dwellers' perceptions, preferences, or attitudes and then inform practitioners [58,61–64].

Accommodating people's interests and ecological principles through design is fundamental to Landscape Architecture practice [47,57]. Design is a powerful tool to imprint and synthesize cultural values, tradition, memory, and beauty in a landscape to make its ecological function and value visually recognizable to users [55,56,65]. Through design, the positive aspects, ecological processes, and functions of NUE can be enhanced, and its negative aspects can be mitigated or eliminated (Box 1) [21,48,54].

Design can also be a relevant tool for NUE investigation (e.g., understand the ecosystems' dynamics and evolution, quantify ecological novelty and aesthetic quality, test design and management options, etc.). Innovative strategies and solutions to approach novel systems can be conceptualized through "designed experiments" that allow collaboration between researchers and practitioners, exchange of knowledge, and complementation of experimentation techniques [47,65]. According to Felson and Pickett [65], "designed experiments" can be developed as socially and politically desirable projects to respond to the specific dilemmas of a particular location and enable a harmonious melding of the scientific process with artistic, aesthetic, cultural, political, ecological, and/or social goals (Box 2) [45,46,48,68,69]. "Designed experiments" can be integrated with routine urban construction and maintenance, reducing or eliminating the cost of experiments. Thereafter, the success and performance of design experiments can be evaluated to improve the delivery of selected ecosystem services and mitigate disservices, minimizing risks and uncertainties, and creating a learning loop that allows adjustment of strategies as new knowledge, data, and measurements are obtained [53,54,65].

**Box 1.** Landscape Park Duisburg-Nord (Germany).

The Landscape Park Duisburg-Nord (Latz+Partner, 1990–2002) [66], once a degraded and abandoned industrial site, is now a public park that combines cultural and ecological objectives and brings people closer to a novel nature [48,50]. The Landscape Park represents an example of a groundbreaking design project in Germany that embodies the opportunities of designing and managing NUE in post-industrial landscapes [51]. Since its creation, the park has inspired other design projects worldwide (e.g., Völklinger Hütte World Heritage in Germany, Lago Ex-SNIA in Italy, Hongmei Cultural Creative Park in China, and Nowadays in the USA) [51,53,66], originating a new aesthetic vision where disruptive and wild landscape fragments are merged in the proposed design rather than being obliterated (Figure 1a). This way, instead of giving this place a completely new identity, the industrial past was reinterpreted, celebrating and preserving the region's history and memory for future generations and for supporting economic activity including tourism. Roads, railways, and spontaneous vegetation already present in the site were integrated into the project's proposal, and new uses and purposes were assigned to existing structures and equipment (Figure 1b–e). Even though biotic and abiotic thresholds have been crossed, the variety of habitats in the park has welcomed a vast diversity of flora and fauna species and novel combinations of native and nonnative plants are supporting multiple and essential ecological processes [50,67].

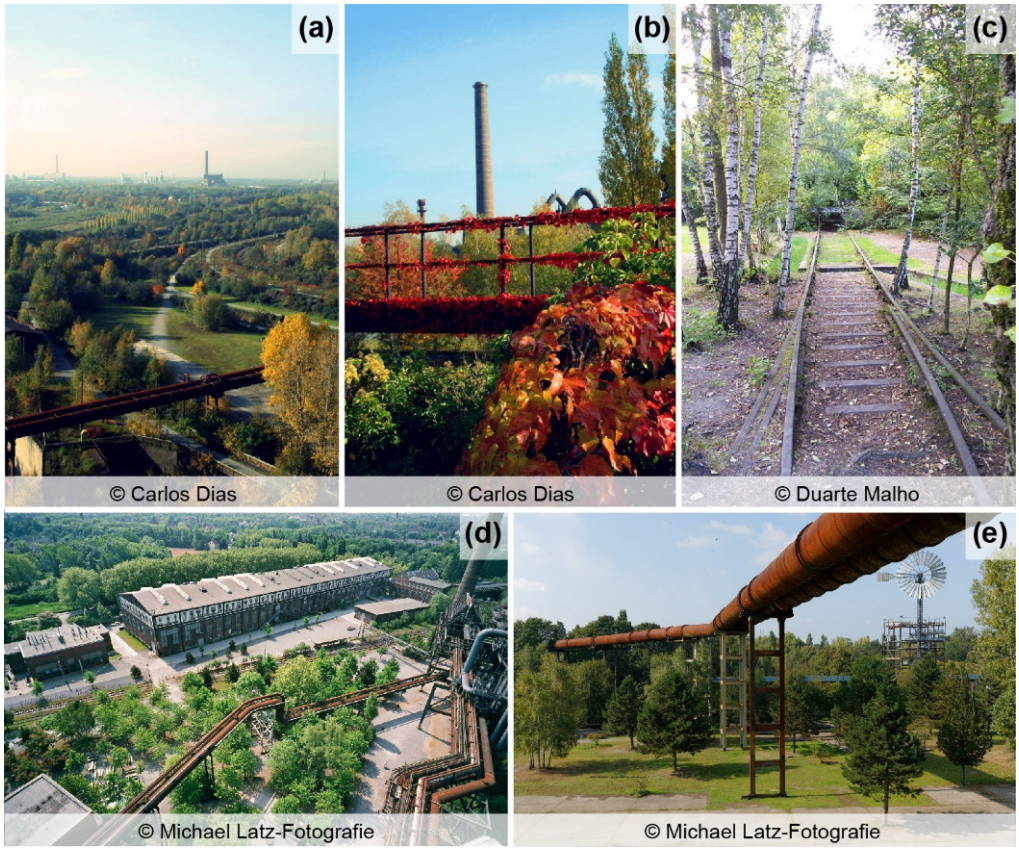


**Figure 1.** (**a**) The post-industrial landscape and scenery at the Landscape Park Duisburg-Nord; (**b**) Vegetation evolving and taking over existing elements; (**c**–**e**) Railways, machinery, old pipes, and industrial structures merged into the landscape and coexisting with the involving novel plant communities. Reprinted (Figure 1d–e) with permission from ref. [66]. Copyright 2021 Michael Latz-Fotografie.

**Box 2.** Wild Gardens at the University of Porto (Portugal).

In former vacant lands within the campus of the School of Sciences of the University of Porto (Portugal), two sets of small-scale experimental gardens with different characteristics and conditions were installed between 2009–2010 [71,72]. The Wet Wild Garden at the north (Figure 2a) and the Dry Wild Garden at the south (Figure 2b) were created combining ecological and aesthetical goals with low cost and minimum intervention. The project design took advantage of existing vegetation and construction materials left behind in the site and resorting to the plantation of strategic native species (e.g., *Quercus suber*, *Fraxinus angustifolia*, *Arbutus unedo*). Native and nonnative spontaneous vegetation was welcomed in the garden over time, eliminating aggressive invasive herbaceous species that were limiting native species development. Inspired by natural ecological succession and through an adaptive and sustainable design and management, these novel urban ecosystems have been evolving and providing biodiversity, habitat, and resources to wildlife (e.g., reptiles, birds, butterflies), contact with nature for the academic community and visitors, and a chance to learn and experience with a living laboratory. So far, these wild gardens have allowed the designers to closely survey and monitor flora and fauna dynamics, evolution, performance, and interactions. And to test materials, management strategies (e.g., cut or no cut, irrigation or no irrigation), and new forms of aesthetic stimulation.

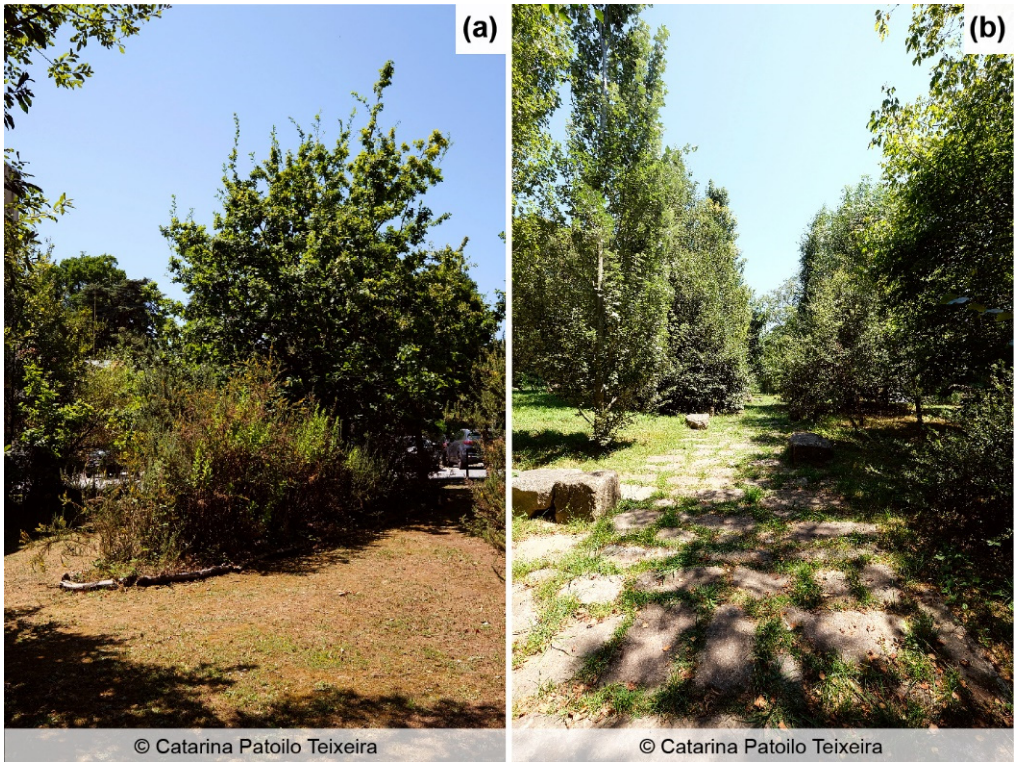


**Figure 2.** (**a**) Wet Wild Garden—Dead tree logs were used to delimitate areas to cut and areas for natural regeneration; (**b**) Dry wild garden—Paths were created using reclaimed materials such as granite stones and the tree and shrub layers were gradually developed resorting to strategic plantings carried out by Landscape Architecture students.

The implementation of designed experiments in complex environments that are virtually impossible to replicate in controlled settings represents an opportunity to observe the unexpected outcomes resulting from human-nature interactions in NUE, or NE (Box 3) [48]. Monitoring NUE dynamics in the real and challenging urban world is a step forward in urban ecology to understand how these ecosystems will respond and evolve based on different design options or management measures, and when exposed to a variety of urban drivers of change or types of public use. For instance, based on observations of his implemented projects (e.g., Parc André Citroën in Paris and Parc Henri Matisse in Lille), the Landscape Architect Gilles Clément tested combinations of species and design approaches that later informed his theoretical work about abandoned spaces that are welcoming to biological diversity (third landscape) [48,49].

**Box 3.** Hart-Miller Island in the Chesapeake Bay, Baltimore, Maryland (USA).

The project "Seeding Specificity: Materials and Methods for Novel Ecosystems" by Mahan Rykiel Associates' team [73] shows how restoration strategies for novel ecosystems can be designed and calibrated based on in situ experimentation and considering the specificities of a real and challenging project site, soils, and floristic palette. By investigating seed germination rates in Hart-Miller Island in the Chesapeake Bay, Baltimore, Maryland (USA), the team used the research findings to develop customized seed mixtures and a seeding plan for this landscape constructed from sediment. First, field research was conducted to assess the biogeochemical systems of the project's site as a natural analog reference site was lacking (Figure 3a). Then, collected data informed the restoration strategy (Figure 3b), which intended to design a living landform to diversify the plant community structure and to stratify the site's geohydrology. The planting design was organized into three types of grasses and forbs species assemblages (wet specialists, generalists, and dry specialists) with different heights and selected based on the species' tolerances (moisture, pH, and invasive pressure) to survive the complex conditions of Hart-Miller Island.

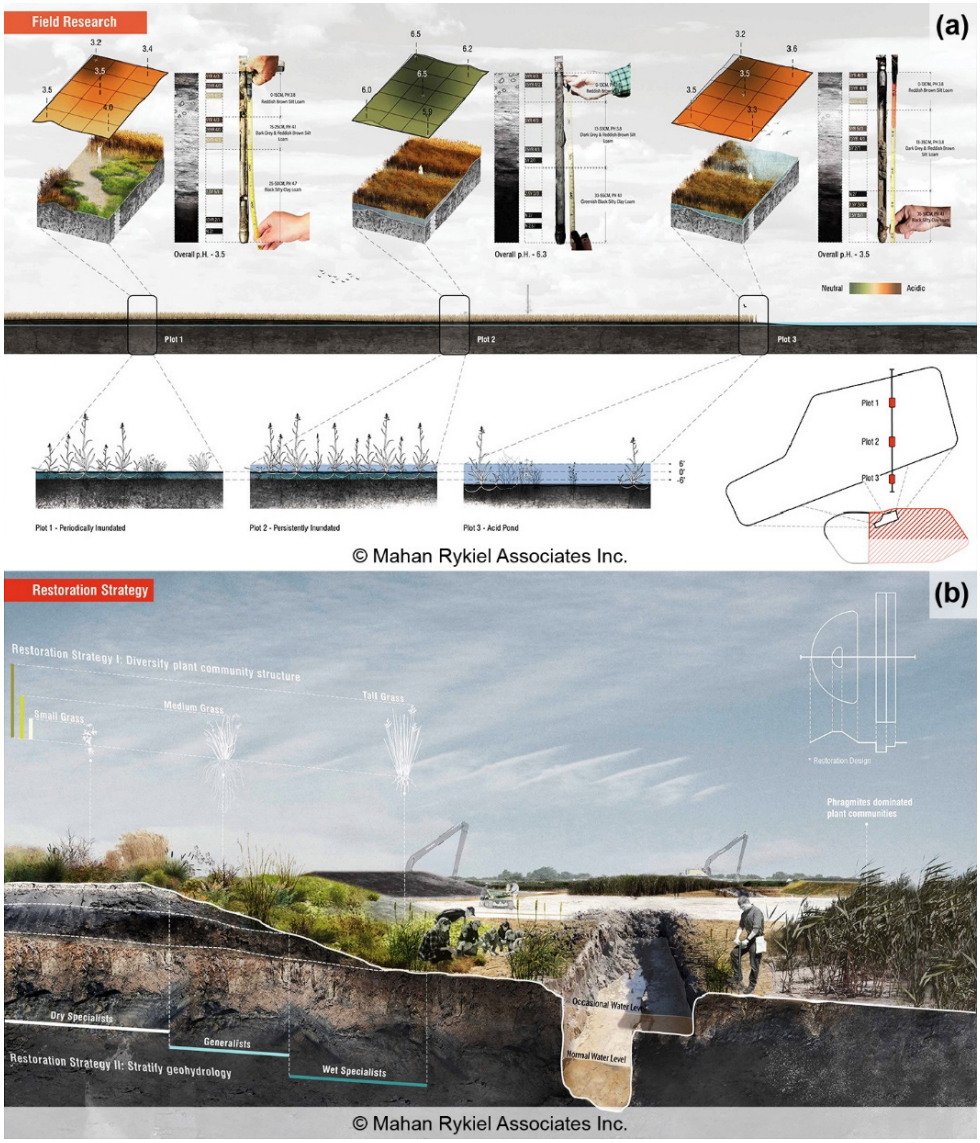


**Figure 3.** Project working images and diagrams regarding (**a**) field research and (**b**) restoration strategy. Reprinted with permission from ref. [73]. Copyright 2021 Mahan Rykiel Associates Inc.

In collaboration, scientists and practitioners can test and monitor the integration of NUE in the green infrastructure of cities, which allows for the reinforcement of a network of multifunctional urban green spaces for increased biodiversity, ecological connectivity, and public access [54]. Since the 1970's Landscape Architects have developed practices for the remediation of contaminated urban environments, knows as "brownfields" (e.g., Gas Works Park in Seattle, Seattle, WA, USA). In this respect, Kowarik [52] provides evidence from a variety of NUE from distinct backgrounds (e.g., vacant lots, fortresses, railway areas, etc.) that, after multi-targeted designed interventions and vegetation management (e.g., focusing on biodiversity conservation, cultural heritage, nature experience, and environmental education) have become accessible to people and integrated into Berlin's urban green infrastructure. Examples from Berlin distanced from the traditional design of urban green spaces include the Natur-Park Südgelände and, in the "Green Belt Berlin", the Mauerpark and the Park am Nordbahnhof [48,70]. These former undervalued vacant lands and transportation links in Berlin were transformed into green spaces fundamental to the urban biodiversity and ecological connection while also providing invaluable functions to Berlin's inhabitants. Their design was conceived reflecting largely on their history (e.g., preserving remnants of railways, walls, and historical pavement), integrating existing

ruderal plant communities and mature native and nonnative tree stands and creating path systems for visitors' access [51,70].

Opportunities for experimentation also arise to investigate the involvement of urban dwellers in the design experiment, communicating the project goals and benefits for the surrounding community, consequently encouraging public and political support [65]. Or to assess NUE potential in the face of uncertain and context-specific climate change effects, extreme weather, or other environmental stresses [5,53,74]. The emergence of novel assemblages of species is either limited or facilitated by extreme abiotic and biotic conditions that act as environmental filters, making NUE pre-adapted to the location where they emerge and, in many cases, also able to mitigate the negative impacts at the base of its origin (e.g., pollution or hot and drier conditions) [48,74]. Existing and spontaneous vegetation can be accommodated and enhanced in the designs instead of replaced, ensuring that the plant communities are more tolerant and adapted to extreme urban conditions, while also providing models to address climate change adaptation and mitigation [51]. In the USA, an undeveloped section of the Liberty State Park in Jersey City constitutes an opportunity to design and manage NUE integrating the existing vegetation already adapted to the local conditions [48]. Even though this former railway site is contaminated with high metal concentrations, the novel assemblages of species that evolved there display great functional diversity and are pre-adapted to the site's environmental stress (i.e., the plants can either avoid or sequester the soil metals) [48,75].

Experimentation through design can support the development of methods and tools to identify and quantify NUE across different types of urban green spaces, thereby assisting the evolution and acceptance of this concept, contributing to a clearer definition of NUE, and strengthening the pertinence and utility of the concept to address contemporary environmental problems such as climate change and pollution. Therefore, this decisive link and common ground between science, nature, and society, ecology and aesthetics, can be established through design in Landscape Architecture [47,48,56]. Without bridging these gaps, the successful application of the NUE concept in urban landscapes and urban policies will be limited, and the NUE utility and relevance will remain questionable by critics of the concept [14].

In the same way, Landscape Architecture can contribute to this discussion and the application of the concept in urban landscapes, NUE can also be regarded as an opportunity in this field. Even though Landscape Architects have already been working with novel assemblages of species and environmental conditions in the past (without labeling them NUE) [49–51,53,70], the NUE concept and terminology is still largely unknown among Landscape Architects. The application of the NUE concept has not yet found its clear way to the practical activity, as traditional and outdated conceptions of nature may be limiting progress [48]. We briefly mention some promising examples where Landscape Architecture has already contributed to this subject. It is, however, urgent that Landscape Architecture continues to embrace the design and management of new forms of urban nature, positioning the field in a current and highly relevant debate and emphasizing the profession's role in promoting socially resilient cities in this age of humans, the Anthropocene.

## 4. Concluding Remarks

Even though NUE are widespread worldwide and may soon become an unavoidable reality, many challenges and barriers still prevent their acceptance [20]. Although it may be easier to ignore NUE because they are different, inconvenient, or a wake-up call regarding humanity's role, we can opt to recognize them as opportunities for welcoming new forms of urban nature and for research and experimentation that will inform future paths [4,5]. We argue that unanswered questions represent opportunities in which Landscape Architecture may contribute with creative perspectives. Ultimately, the spectrum of Landscape Architecture action can cross many areas of knowledge, accede useful tools, facilitate dialogues, create new designs and design approaches, and bridge existing gaps between science, people, and nature.

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