



# Exploring urban novel ecosystems: Understandings, insights and recommendations for future research and practice

Melissa Pineda-Pinto<sup>a,b</sup>, Marcus Collier<sup>a,\*</sup>, Clair Cooper<sup>a,c</sup>, Mairéad O'Donnell<sup>a</sup>, Fiona Nulty<sup>a</sup>, Natalia Rodriguez Castañeda<sup>a</sup>

<sup>a</sup> Discipline of Botany, School of Natural Sciences, Trinity College Dublin, University of Dublin, Ireland

<sup>b</sup> Melbourne Centre for Cities, Faculty of Architecture Building and Planning, The University of Melbourne, Victoria, Australia

<sup>c</sup> Net Zero Industry Innovation Centre, Teesside University, Middlesbrough, United Kingdom

## ARTICLE INFO

### Keywords:

Urban novel ecosystems  
Delphi  
Knowledge-holders  
Cities  
future research priorities  
Urban planning

## ABSTRACT

Novel ecosystems are those that have been altered by human activities and have afterwards experienced abandonment or human disuse, allowing for a new assemblage of species to establish. In urban areas, these ecosystems, are commonly found in post-industrial sites, vacant lots, and other unmanaged spaces. The informality of these ecosystems, assumptions of their low ecological value, and associations with negative attributes continue to prevent recognition of their social-ecological value. Although research in the last decade has started to show the potential of novel ecosystems to address several challenges such as biodiversity loss, there remains a need to understand what areas of research are needed to progress our understanding of these ecosystems in urban areas. This paper uses a modified Delphi methodology, in which a panel of knowledge-holders provided their understandings and insights of urban novel ecosystems. Through this process, we distilled key questions for future research and practice that should drive the investigation of these wild ecosystems for improved decision-making. This study sets out recommendations on how to progress the research questions as part of urban transformative agendas in which urban novel ecosystems offer new possibilities for climate experimentation, social-ecological stewardship and biodiversity conservation.

## 1. Introduction

As quintessential characteristics of the Anthropocene, landscape modification and land-use change represent the biggest threats to the world's biodiversity and supporting ecosystems. They are socio-physical processes that leave behind spaces that no longer resemble any historical ecological remnants. Usually, these spaces have been depleted, damaged and transformed to such a degree that they have entered a new state, a new regime (Erle & Navin, 2008; Hobbs et al., 2006; Morse et al., 2014). In cases in which these spaces have been abandoned or have a less intense degree of human intervention, a new nature often forms. What are increasingly being referred to as 'novel ecosystems' are the product of human interventions in which an absence of management for a period of time, has allowed for a system of self-organising, novel assemblage of species to emerge (Hobbs et al., 2013). These novel habitats are considered no-analogue, meaning they have a species composition that historically has not occurred in that place (Hobbs et al., 2013; Williams &

\* Corresponding author.

E-mail addresses: [melissa.pinedapinto@unimelb.edu.au](mailto:melissa.pinedapinto@unimelb.edu.au) (M. Pineda-Pinto), [marcus.collier@tcd.ie](mailto:marcus.collier@tcd.ie) (M. Collier), [Clair.Cooper@Tees.ac.uk](mailto:Clair.Cooper@Tees.ac.uk) (C. Cooper), [ODONNM12@tcd.ie](mailto:ODONNM12@tcd.ie) (M. O'Donnell), [NULTYF@tcd.ie](mailto:NULTYF@tcd.ie) (F. Nulty), [RODRIGN1@tcd.ie](mailto:RODRIGN1@tcd.ie) (N.R. Castañeda).

Jackson, 2007).

In urban areas, novel ecosystems are a universal phenomenon remarkably ever-present, and ever-emerging. They are populated by a wild, unmanaged, informal, and unplanned nature that has re-emerged through different interactions across social and ecological systems (Ahern, 2016; Perring et al., 2013; Rupprecht & Byrne, 2014). Usually, temporary pauses in human use or different forms of land abandonment due to socio-economic drivers like city shrinking, land-use changes, and shifts in socio-demographics have provided the space for this spontaneous nature to emerge and evolve. They commonly occupy post-industrial sites, vacant lots, urban wastelands and other interstices or in-between spaces, such as the sides of railway lines, rivers and creeks, and smaller spaces, like pavement verges and cracks (Jorgensen & Keenan, 2012). On many occasions, these novel ecosystems tend to be valued through narratives of regeneration and greening (Pineda-Pinto et al., 2023), which consider these spaces as abandoned, in misuse/disuse, or empty, reflecting a waiting in time for them to become something 'else', something 'better', something 'of value' (Ganko, 2020). This can in turn have justice implications and lead to gentrification (Lee & Newman, 2021) and overall displacement of social and ecological communities (Draus et al., 2020). Research in the last decades, however, has seen these ecosystems resurface as spaces with multiple values and benefits and as part of the urban mosaic (Kowarik, 2023; Teixeira & Fernandes, 2019), helping to challenge negative connotations associated with these spaces. A review of research on the biodiversity of urban wastelands has demonstrated the biological richness of these sites and their potential to promote biodiversity conservation in cities (Bonthoux et al., 2014). They are also recognised for their adaptive capacities and potential for building social-ecological resilience (Collier, 2015; Kennedy, 2022). This recognition also stems from the fact that novel ecosystems have been studied from different disciplinary perspectives, bringing in different ways of understanding them such as *wild spaces* as spaces with 'an absence of human intervention and where species can respond instinctively and self-assemble' (Threlfall & Kendal, 2018), or *informal green spaces* viewed as 'social-ecological entities' with no formal ownership and governance arrangements (Rupprecht & Byrne, 2014), or *ambivalent landscapes* associated with the contradictory senses of ruin and liberation they generate in derelict sites recolonised by nature (Jorgensen & Tylecote, 2007).

Enmeshed in this diversity and polarity of views is the fact that novel ecosystems, their understandings and management, are part of an already complex system (Marín & Finlayson, 2019). Metropolitan urban areas are confronted by complex issues that require multidimensional approaches, cemented in research that offers practical solutions, guidelines, and parameters for planners and policy-makers (Collier et al., 2013). Within the array of complexities of biodiversity conservation, particularly from the planning, management, creation and protection of green spaces, addressing novel ecosystems may appear to be bringing an additional burden of complexity. Furthermore, the idea of novel ecosystems causes discomfort, leading to ecological controversy and policy polarisation (Aronson et al., 2014; Bridgewater et al., 2011; Murcia et al., 2014). As a result, this translates to a lack of clarity in the management, planning, and restoration (Seastedt et al., 2008) and a 'lack of research investment in urban areas' (Teixeira & Fernandes, 2019). However, the social, ecological and technological systems and dynamics that shape and reshape cities generate, eliminate and recreate novel ecosystems continuously (Pineda-Pinto et al., 2021). A lack of recognition and reckoning with urban wild ecosystems may hinder a better understanding of, and finding alternative pathways for, their future, and as a result of our collect future in the Anthropocene. This study is thus positioned and contributes to the need for research agendas and calls to action that revisit biodiversity to achieve and sustain just futures (Wyborn et al., 2021).

Because the novel ecosystem debate has been accused of generating more discussion than insights or solutions (Backstrom et al., 2018; Collier, 2015; Murcia et al., 2014), our study is designed to focus on mapping what we need to know for research and practice to clarify and prioritise knowledge and action through expert-based evidence in order to begin to move forward from barriers and controversies. We use a modified Delphi approach to improve our understanding of urban novel ecosystems and their conceptual and practical role as ecosystems in cities. Through a 3-phased process carried out with experts or knowledge holders, this study aims to map research needs that will assist decision-makers with managing complex concepts and phenomena. It does this by first exploring the diverse experiences and understandings of urban novel ecosystems through the participants' knowledge and secondly by understanding what lines of inquiry are needed to advance our knowledge of novel ecosystems. In the following sections, we detail the steps undertaken to collect data through a modified qualitative Delphi approach. We then present the main findings in two parts: firstly, we present the plurality of views and understandings shared by the participants' experiential knowledge of novel ecosystems. In the second part, we present a set of research questions which stem from a synthesis of the barriers, challenges, opportunities and research needs expressed by the participants. These findings are then discussed in light of the role cities have to play in advancing urban transformations and propose a set of recommendations to drive the investigation of urban novel ecosystems for improved decision-making.

## 2. Methods

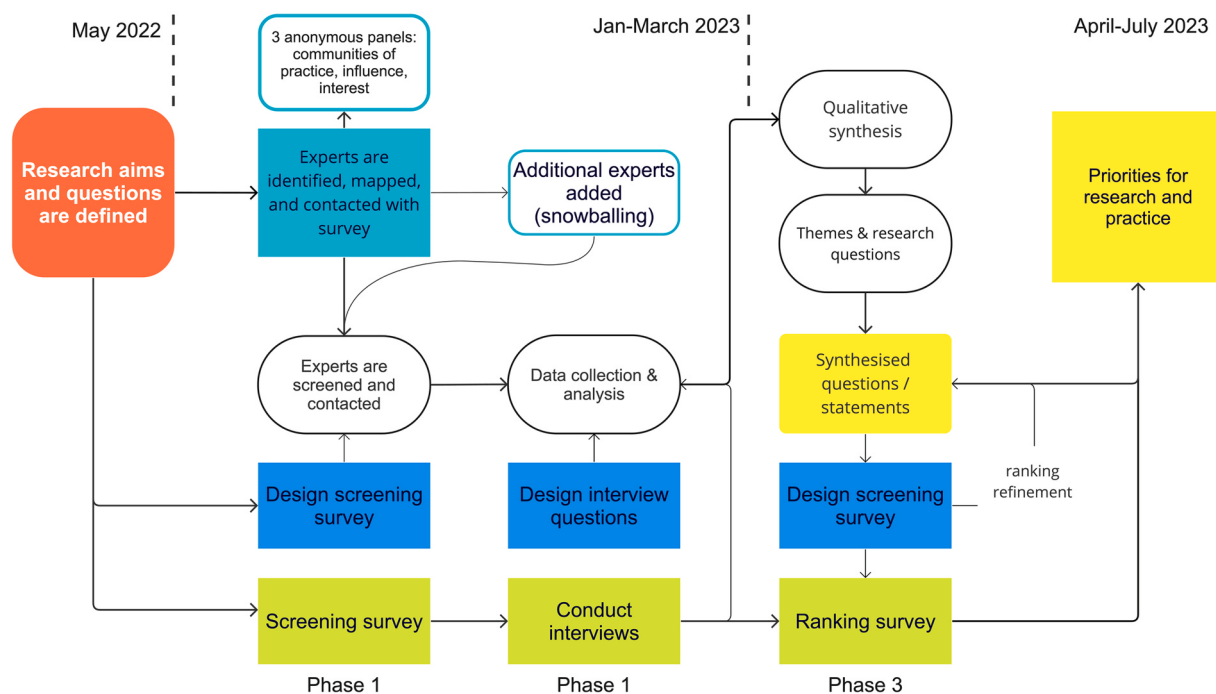
### 2.1. Research design and strategy

This study uses a qualitative and quantitative expert-based methodology based on a modified version of the Delphi method. The Delphi method is an expert knowledge elicitation technique that uses an expert-based pool of people with knowledge and expertise in the topic to gain insight and provide informed evidence on the needs and priorities for research and practice on issues that are contested and occur at a global scale (Mukherjee et al., 2018). It is a research process that involves several rounds of iterations amongst anonymous panels of experts to find a degree of consensus around a complex problem (Turoff & Linstone, 1975). Since its origins in the 1950s, it has taken many directions, with many of its elements such as the number of rounds, disciplinary focus, and types of analysis evolving to fit the type of research being conducted (Beiderbeck et al., 2021). Within this context, the approach is important for providing informed knowledge for policy and decision-makers.

The modified Delphi approach we used for this study departs from the traditional technique by drawing from approaches that seek more active policy change, bringing research priorities front and centre, such as the policy and change-oriented Delphi (Maxey & Kezar, 2016). Given that novel ecosystems continue to be a contested and evolving concept and phenomenon which is moreover underscored by the multidimensional complexity of urban systems (Teixeira & Fernandes, 2019), we argue that improving our knowledge about them can assist urban planning agendas by highlighting the importance of these ecosystems for future urban transformations. As such, our study aims to assist urban researchers, planners and practitioners in determining a research agenda that can become a part of their quest for sustainable futures. We do this through a layered hybrid research approach (Flood et al., 2023) that includes three research phases (a screening survey, semi-structured interviews, and a ranking survey) in which we explore different research questions needed to improve our understanding of these spaces. This expert knowledge elicitation technique can encourage imagination and allow explorations of what research is needed and how it can contribute to building more desirable futures (Wyborn et al., 2020, 2021). See Fig. 1 below for the research strategy.

## 2.2. Phase 1: ‘Expert’ Identification, recruitment and preliminary data collection

The first phase used a screening survey to filter participants, establishing their knowledge base, interest in participation, and asking them to identify a key research question that should be asked concerning urban novel ecosystems. To map, identify and contact knowledge holders we created a knowledge resource worksheet that would form our database of experts. Given that novel ecosystems, as concept and phenomena, continue to be surrounded by controversy and are not considered in many fields of research and practice, such as planning or design, the best approach to identify individuals working in this area is through their scholarly work. Therefore, the initial selection process consisted of identifying experts working in academia and research, who were easily identified through their publications and work. This initial selection, based on the judgement of the investigators, is considered an acceptable approach within a Delphi study (Hsu & Sandford, 2007). We then used a snowball sampling technique to further identify more participants to add them to our knowledge database (Clark et al., 2021). This was done by asking survey respondents to suggest other ‘experts’ from different areas/levels, such as practitioners (planners, designers, ecologists), academics, and members of community groups or other organisations working with these topics. A snow sampling technique was used as an approach to address potential selection bias. Attempts to include knowledge-holders from different geographic locations were also pursued by actively seeking voices from the Global South. This was a challenge however and the majority of participants willing to participate came from the Global North, and as such the results in this study reflect this geographical bias. The survey was designed to understand the experts’ current work, their work with novel ecosystems, how the concept is viewed through their profession and identify knowledge gaps of urban novel ecosystems by posing a key question that should be asked concerning these spaces (see Appendix A for further details). This gave us a way to ensure that the potential interview participants had expertise with novel ecosystems, from different levels, sectors, and types of practices. Through this screening survey, participants were also asked if they would consent to a face-to-face interview (35–40 minutes). The



**Fig. 1.** Research strategy (based on modified Delphi studies and reviews such as (Flood et al., 2023; Grace et al., 2021; Maxey & Kezar, 2016; Zartha Sossa et al., 2019).

survey was sent to 75 experts, with 40 completing the screening survey. The survey distribution commenced on the 7th of July 2022 with the last survey completed on the 19th of April 2023.

To create our knowledge-holder panels, we used the literature on the landscape of practice that brings together actors with different degrees of competence, types of knowledge and occupations (Wenger-Trayner et al., 2015). We then categorised them into three communities based on their work background in terms of influence (e.g. policy-makers), practice (practitioners, e.g. architects, ecologists), and interest (researchers, academics, community groups/activists) (Wenger-Trayner et al., 2015). It is important to clarify the boundaries or spaces of overlap (Wenger-Trayner et al., 2015) between the panels and how many, if not most of them, have experience across the different domains, either through work history/experience or through the different roles they carry out. Table 1 details the number of participants, expertise and skills, their classification into the panel types, and the country where they mostly conduct their work (for more detailed information on the panels and other aspects of this phase, please refer to Table S1, S1

**Table 1**

List of participants by community type (influence, practice, and interest), experience and geographic location. See S1 Appendix A (Table S1) for details on participation numbers per phase.

|    | Panel/<br>Community    | Country                | Disciplinary background / areas of expertise                                                                                                                            |
|----|------------------------|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Practice/<br>Interest  | Ireland                | art; sculpture; teaching; environmental, multispecies approach                                                                                                          |
| 2  | Practice               | USA                    | stewardship; citizen science; urban foraging, soil contamination, land remediation, plant ethnography, resilience and ecological storytelling                           |
| 3  | Influence              | USA                    | biology; restoration; seed collection                                                                                                                                   |
| 4  | Practice               | Ireland                | art; teaching; community engagement; policy; justice                                                                                                                    |
| 5  | Influence              | USA                    | botany, plant ecology; restoration, government                                                                                                                          |
| 6  | Influence              | USA                    | ecology, stewardship; government                                                                                                                                        |
| 7  | Practice               | Colombia               | landscape architecture, landscape urbanism; activism                                                                                                                    |
| 8  | Interest/<br>Practice  | USA                    | environmental engineering, urban ecology, arts and humanities; multispecies urbanism, urban plant communities, and the role of art/culture in environmental stewardship |
| 9  | Influence              | Costa Rica             | ecology; policy-making                                                                                                                                                  |
| 10 | Influence/<br>Practice | USA                    | landscape design, construction; rewilding                                                                                                                               |
| 11 | Influence/<br>Interest | USA                    | landscape architecture, human dimensions; research; government                                                                                                          |
| 12 | Influence/<br>Practice | Luxemburg/UK           | ecology, horticulture, design; consulting                                                                                                                               |
| 13 | Influence/<br>Interest | Ireland                | natural science, landscape architecture; infrastructure development                                                                                                     |
| 14 | Influence              | Ireland                | urban planning; volunteer engagement                                                                                                                                    |
| 15 | Interest               | Italy                  | ecology, forestry science, urban planning                                                                                                                               |
| 16 | Interest/<br>Influence | Australia              | city policy, governance, practice and research; biodiversity, genetics, ecology, cities / urban systems, climate change                                                 |
| 17 | Interest               | Finland                | urban ecology; social-ecological systems; climate change                                                                                                                |
| 18 | Influence/<br>Interest | Australia              | research, teaching; horticulture, urban ecology, environmental psychology, geography                                                                                    |
| 19 | Interest               | UK/ USA /<br>Australia | ecology, environmental social sciences; environmental governance and policy                                                                                             |
| 20 | Influence/<br>Practice | USA                    | ecology, conservation, environmental science, and philosophy; science communicator, writer                                                                              |
| 21 | Interest               | Switzerland            | urban ecology, ecosystem services; research                                                                                                                             |
| 22 | Interest               | Germany                | ecology; urban ecology; research; knowledge dissemination                                                                                                               |
| 23 | Interest               | France                 | environmental geography, environmental aesthetics, urban geography; research, management, stewardship                                                                   |
| 24 | Influence/<br>Interest | Australia              | urban planning; social-ecological systems; governance; research                                                                                                         |
| 25 | Interest               | UK                     | geography; research; teaching                                                                                                                                           |
| 26 | Interest               | Poland                 | environmental planning; ecosystem service; green space management; research                                                                                             |
| 27 | Influence              | Ireland                | biodiversity; parks management; community engagement                                                                                                                    |
| 28 | Influence              | Ireland                | ecology; data management;                                                                                                                                               |
| 29 | Influence/<br>Interest | Australia              | urban planning; nature-based solutions                                                                                                                                  |
| 30 | Interest               | France                 | urban ecology, ecosystem services; research, teaching                                                                                                                   |
| 31 | Interest               | Ireland                | planning, environmental policy; research, teaching                                                                                                                      |
| 32 | Practice               | USA                    | horticulture, urban restoration ecology, landscape design/architecture                                                                                                  |
| 33 | Interest               | Germany                | urban ecology, environmental psychology, humanities; landscape planning; research                                                                                       |
| 34 | Practice               | Ireland                | landscape architecture; research, education, practice                                                                                                                   |
| 35 | Practice               | USA                    | zoology, biology, urban conservation; policy advisor; urban planning                                                                                                    |
| 36 | Interest               | UK                     | urban studies; cities and climate change; environment and development; research                                                                                         |
| 37 | Interest               | USA                    | environmental education; student engagement, collaboration                                                                                                              |
| 38 | Interest               | Japan                  | urban planning, urban geography, urban ecology, sustainability, informal urban greenspace; research, teaching                                                           |
| 39 | Interest               | Poland                 | ecology, spatial planning, urban green spaces; research, teaching                                                                                                       |
| 40 | Interest               | Germany                | ecology; research, teaching                                                                                                                                             |

## Appendix A).

## 2.3. Phase 2: face-to-face semi-structured interviews

The second phase of the Delphi process consisted of capturing qualitative data through semi-structured interviews (35–40 minutes). It was possible to arrange and conduct interviews with 27 participants from the 40 who completed the screening survey during the period of 7th July 2022 and 23rd March 2023. The participants were knowledge-holders with experience on the topic of novel ecosystems in cities from different countries around the world: Australia, Canada, Colombia, Costa Rica, France, Germany, Ireland, Italy, Luxembourg, the UK, USA, Switzerland, and Poland. Even though the research aimed to bring a diversity of views from different socio-cultural backgrounds and regions, the majority of survey responses and interview participants came from Europe and the USA. The semi-structured interview was framed around several topics of discussion, with a focus on the participants' responses in the screening survey. First, participants were asked to elaborate on their understanding/experience of novel ecosystems. This was followed by asking them to reflect on their perceptions of urban novel ecosystems through their experience. The following topic for discussion, and the one that is the focus of analysis in this paper, sought to identify the barriers, challenges and opportunities of managing and studying urban novel ecosystems. This was used as a strategy to move forward from barriers and controversies by clarifying and identifying what knowledge and actions are needed to improve our understanding of urban novel ecosystems and develop a template for a future research agenda. To finalise the interview, participants were asked to reflect on the questions they had posed in the initial survey phase and elaborate on how their questions could advance our understanding of novel ecosystems. Interviews were conducted in English and Spanish, and consent was obtained for all interviews.

Qualitative data from the interviews was analysed through a theoretical or analytical thematic approach (Braun & Clarke, 2006). This analyst-driven approach focuses on particular areas of interest and in answering specific questions (Braun & Clarke, 2006). For our research, data was thematically coded to extract multiple challenges, barriers and opportunities of urban novel ecosystems and identify patterns that relate to gaps in knowledge. The challenges, barriers and opportunities were coded and developed into a knowledge base of 65 research questions or areas linked to the social-ecological characteristics and management aspects of urban novel ecosystems (see Table S2, Appendix B, SI). These questions were then categorised into higher-level themes (ecology, perceptions, and management). These coding processes were confirmed by multiple team members with several rounds of iteration to reconsider, adjust and reach consensus.

## 2.4. On-line ranking survey (Phase 3)

Given that a necessary step in the Delphi is to identify priorities and/or consensus to assist policy and planning, it was considered a practical measure to collate and synthesise the 65 questions thematically, prior to sending them to the participants. In addition to their being overlap and repetition within those 65 questions, participant fatigue is a limitation in Delphi studies and asking participants to rank 65 questions was not deemed suitable. Therefore, the design of the survey was the result of a thematic analysis of identifying concepts and categories based on specific questions and ideas expressed by participants during the interviews and the first screening survey and developing general themes (Brady, 2015). A total of 21 questions were set up in the survey across three themes: ecology, perceptions, and planning/management. Participants were requested to rank the seven research questions per theme and to explain their choices, yielding both quantitative and qualitative data between the period of 25/05/2023–20/07/2023. The survey was designed with a 7-point ranking scale of importance, organising 7 questions per theme (Drumm et al., 2022). The importance scale included ranks from essential priority to the lowest priority and all questions had to be ranked and no two questions could have the same ranking. A Likert scale was selected for its useability in qualitative research to define the variables being assessed in terms of significance (Habibi et al., 2014). We conducted autonomous counting (i.e. frequency counting) to determine the most frequent responses (Hannah & Lautsch, 2011). Due to low-frequency responses in extreme Likert-scale categories, we collapsed categories with sparse data by recoding these responses and reducing the number of data categories from 7 to 5 (essential/high, moderate, neutral, somewhat, and low/lowest priorities) (DiStefano et al., 2021; Grimbeek et al., 2005).

Despite this research relying more deeply on qualitative data and analysis to extract the findings (Brady, 2015), the final ranking phase of the research was critical in order to provide policymakers, researchers, and funding agencies with a set of priorities to guide research of urban novel ecosystems. However, in the case of this research, reaching a consensus was not considered essential. Using a subjective criterion, we established two aspects of the research. First, subsequent rounds of questionnaires (to find consensus or refine the questions) would not add more to the research's objective (von der Gracht, 2012). This is in line with a trend in research to use fewer rounds in modified Delphi approaches (Zartha Sossa et al., 2019), because several rounds of consensus can result in participation fatigue and high dropout rates of participants, which can skew and affect the accuracy of the research findings (Hsu & Sandford, 2007). Second, the questions with the most frequent responses in the essential rank scale were considered the most urgent research and pressing needs. As such, we begin the following section by presenting the knowledge-holders' experience and understandings, which offers a baseline understanding of the questions they posed. From this we then present a summary of the 65 questions, which is followed by a presentation of the highest-ranked questions (essential scale), which we bring to the spotlight as the most urgent areas for researchers and policy-makers to focus on.

### 3. Results

#### 3.1. Understandings and experiences of/with urban novel ecosystems

The majority of knowledge-holders who participated in this research have conducted their work in Europe (n=22) and the USA (11), with lower representations from other regions including Australia (n=4), Colombia (=1), Costa Rica (n=1) and Japan (n=1). Participants revealed that memories of play and exploration in these marginal spaces during their childhood, prompted new curiosities for investigating them. Reflecting on his childhood experience, one participant said that ‘...these spaces were so much more interesting than municipal parks. You could discover things, there were surprises and of course, there was a lot more biodiversity to be found’ (1008). Later in life, that link reemerged, and it became intertwined with their professional work. Curiosity also emerged by observing what was happening in a vacant lot, in an unmanaged reserve, or other liminal spaces (e.g. pavement cracks). Observations of these spaces related to the adaptation capabilities of species emerging in disturbed landscapes, and of the biodiversity that some of these ‘wild’ spaces have. This led participants to imagine how these spaces could serve ‘as models for future ecologies’ in cities (1007;1020).

A sense of multispecies justice also emerged in participants’ understandings, with a recognition of autonomy and power to transform and even heal disturbed landscapes, but also deeper ethics that relate to how we frame species inhabiting these novel ecosystems – e.g. invasive, pest, non-native, introduced – and the measures we take to eradicate them. This, participants highlighted, is also tied with how these spaces reflect more complex discussions of ownership, accessibility, and our entrenched biases and proclivity to reproduce binaries in research and practice: native vs invasive, cleaned vs trashed, cared for vs damaged, ordered vs disordered, all which simplifies these ecosystems and our interactions between them either as good or bad.

Similarly, as the literature conceptualises urban novel ecosystems in different ways depending on the discipline or underpinning epistemologies and ontologies, participants spoke of these spaces in diverse ways: as ‘blossomed spaces’ (1010) in relation to the participant’s experience of working with children and these ecosystems, as ‘land in transition’ (1009) or ‘fungible nature’ (1000) or ‘informal green spaces’ (1002) to those with backgrounds in planning and design, or as ‘ephemeral’ (1020), ‘short-lived’ (1005) and ‘immature’ (1005), ‘successional’ (1025) nature or as ‘unnamed or grey-zoned areas’ (1015) in reference to fast-growing species that thrive in disturbed, harsh and many times contaminated environments. Interestingly, for our participants from Latin America, the ways of describing these spaces differed from those of English-speaking participants. They were described with concepts like regenerative nature, spaces for undisturbed successional nature to thrive, refuges, spaces of spontaneous regeneration and spaces of association (1021; 1023). Those working in the community of practice and interest, as artists, landscape architects, gardeners, and stewards, view and engage with these spaces as place-making spaces, places to be uncomfortable (1012; 1022), places for healing (1027), ‘uncurated spaces’ (1026) and places to ‘play and hide’ (1022).

They were also seen as spaces of opportunities to reconnect with nature, with participants highlighting how they experienced positive emotions in these spaces. Participants, in particular those with backgrounds in ecology, made references to these spaces as enablers of the ‘wow effect’ (1001), producing feelings of happiness, wonder and awe (1001;1004;1005;1006). They were regarded as stepping stones for dispersion and natural succession, but several participants highlighted that this was not always positive in that they acted as ‘channels for invasive species’ (1000;1019;1025). Across participants, they were regarded as real-time living laboratories to explore which and how species survive in these environments. Living laboratories can also serve as a template for exploring how urban ecosystems can be designed and planned for uncertain urban futures. Learning from and protecting those ecosystems that are already showing us what works best was deemed critical. However, learning from these ecosystems and future thinking also needs to bring ethical considerations, long-term thinking and plural-values perspectives. Participants discussed the historical legacies of contamination of these sites and their links to marginalised communities and how reactivating these sites presented ethical and legal dilemmas. As one participant suggested, it is critical to define ‘effective management strategies that are biocultural, ethical and flexible’ (1022). Future planning can consider these sites ‘to reduce massive disparities and grow food, support native habitat’ (1027) and provide multiple other ecosystem services for underserved communities.

#### 3.2. Research questions to inform planning and practice of urban novel ecosystems

Understanding our participants’ experiences and perceptions of urban novel ecosystems was an important link in identifying and synthesising areas for further research. The questions collated throughout this research process are presented as a set of research areas for urban planners, policy-makers and researchers to advance our understanding of urban novel ecosystems. They are not ground-breaking research areas that differ from other types of ecosystems but offer a template to not only recognise the importance of studying them but also to enhance our knowledge that can help us develop innovative solutions that integrate them as part of urban agendas seeking transformation. The questions are discussed below organised into three categories based on the themes: ecology, perceptions, and planning and management.

##### 3.2.1. Ecology

The majority of the research questions concerned with the ecology of urban wild ecosystems range from site-specific considerations to larger-scale priorities. Site scale needs include assessing the biodiversity and functioning of species inhabiting these spaces. It was significantly highlighted that identifying what species are present, along with their numbers and dynamics, would shed light on the ecological value of these spaces, something that is currently lacking or just emerging in some site-specific studies. Participants highlighted the importance of understanding if these ecosystems are pools and conductors of invasive species and if these are causing more harm than benefits. At a site level, participants felt it is also important to understand the nutrient cycling flows characteristic of

these ‘degraded’ or impacted ecosystems. In many cases, what has led to novel ecologies emerging in the first place has been the overuse and extractive activities that often leave behind highly polluted and toxic conditions, including low-quality soils. Understanding this, as well as which species can withstand these environments, how they emerge, evolve, repair or remove toxic elements, and give way to other species is research deemed to be critical by the experts. Larger scale considerations include looking at the ecological connectivity potential of these sites. Also, from an interconnected perspective, the experts highlight the value of these spaces to mitigate and provide adaptation alternatives to climate change impacts and other disturbances. Finally, ecosystem services are also regarded as an overall significant research area that could help collect both ecological and social data. The difference in ecological form and function across unmanaged and more formal and managed spaces was puzzling for participants. Shedding light into where and why these differences are happening can provide evidence as to which types of interventions can enhance the benefits of a site or manage them in a way that enhances the preferred benefits. Similarly, it was important for several participants to increase ecological knowledge overall to be able to compare their ecological potential in relation to more formal and managed green spaces.

### 3.2.2. Perceptions

The underlying characteristic of the research questions in the perceptions theme is the recognition of the importance of people-nature connections. It is deemed critical to understand further how people value, respond to, and interact with these ecosystems in urban environments. For instance, it is significant for many participants to understand the biophysical and cultural elements that influence different ways of valuing these spaces, how these in turn affect the senses, positively or negatively, and how this then mediates how people may interact with them. For example, our contributors from Australia highlighted how the native vs non-native debate is critical in this region and this in turn affects the perceptions, narratives and actions taken to address these ecosystems. This is linked to the types and degrees of ecological knowledge and how this influences perceptions and attitudes towards these ecosystems. Several experts considered that knowledge, which is also mediated by culture and training having been linked to sociocultural factors more generally, would be very important to study. The relationship between perceptions of these spaces and health, well-being and social cohesion was also a point made by participants, discussing if different valuations of these spaces affect health and well-being, but

**Table 2**

Research questions or areas for investigating urban novel ecosystems and their associated rankings. Questions 1–7 (ecology-focus); 8–14 (perceptions-focused); 15–21 (planning/management-focused).

| Research Questions                                                                                                                                        | Priorities     |          |         |          |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|----------|---------|----------|------------|
|                                                                                                                                                           | Essential-High | Moderate | Neutral | Somewhat | Low-Lowest |
| 1 What biodiversity do urban wild spaces support?                                                                                                         | 14             | 3        | 2       | 1        | 1          |
| 2 What are the factors that influence ecosystem composition and functioning in urban wild spaces?                                                         | 8              | 2        | 10      | 0        | 1          |
| 3 What is the role of urban wild spaces in improving urban ecological connectivity?                                                                       | 8              | 5        | 1       | 5        | 2          |
| 4 What ecosystem services do urban wild spaces provide?                                                                                                   | 8              | 5        | 1       | 2        | 5          |
| 5 How do urban wild spaces cope with acute climatic disasters, contamination incidents and other extreme conditions?                                      | 3              | 2        | 1       | 5        | 10         |
| 6 What are the functionings of species living in urban wild spaces?                                                                                       | 1              | 0        | 6       | 3        | 11         |
| 7 What are the nutrient cycling capabilities of urban wild spaces and their effect on biodiversity?                                                       | 0              | 4        | 0       | 5        | 12         |
| 8 What are the landscape elements that influence changes in value and perceptions of urban wild spaces and their effect on how people interact with them? | 15             | 2        | 1       | 1        | 2          |
| 9 Which types and degrees of ecological knowledge relate to the way that urban wild spaces are perceived and influence how we interact and care for them? | 3              | 3        | 6       | 5        | 4          |
| 10 What is the relationship between values and perceptions of urban wild spaces and justice?                                                              | 6              | 1        | 3       | 5        | 6          |
| 11 What aspects of urban wild spaces have the potential to increase our sense of wonder, attentiveness and appreciation of nature?                        | 8              | 3        | 6       | 1        | 3          |
| 12 Which ecosystem services provided by urban wild spaces are recognised and valued by different groups of people?                                        | 5              | 5        | 2       | 3        | 6          |
| 13 How do perceptions and values of urban wild spaces vary between socio-cultural factors?                                                                | 1              | 5        | 1       | 4        | 10         |
| 14 How do people perceive informal wild spaces in terms of wellbeing, social cohesion and health?                                                         | 4              | 2        | 2       | 2        | 11         |
| 15 What factors should influence the management, planning and design of urban wild spaces?                                                                | 12             | 3        | 2       | 1        | 3          |
| 16 How can urban wild spaces become more visible, accessible and attractive for people in order to increase nature connectedness and stewardship actions? | 5              | 3        | 5       | 4        | 4          |
| 17 Which law and land planning mechanisms can enable urban wild spaces to be more socially inclusive as well as biodiverse ecosystems?                    | 9              | 2        | 3       | 3        | 4          |
| 18 How can urban wild spaces be managed so they retain their informal and wild nature?                                                                    | 6              | 4        | 3       | 1        | 7          |
| 19 What are the ethical considerations for managing urban wild spaces?                                                                                    | 3              | 2        | 3       | 1        | 12         |
| 20 How can ecosystem composition and functioning in urban wild spaces serve as a guide for future green space city planning?                              | 6              | 5        | 3       | 3        | 4          |
| 21 What variables should be measured in urban wild spaces to inform different policy-making outcomes?                                                     | 1              | 2        | 2       | 8        | 8          |

also if these spaces may improve health outcomes.

### 3.2.3. Planning/Management

The last grouping of research questions reflects the importance of planning, management and governance of urban novel ecosystems. This theme is very much linked to the previous questions. In a way, understanding the ecology of these wild ecosystems and people's perceptions, knowledges and social characteristics, provides the baseline knowledge to guide informed decision-making for city planning. Within this theme, research questions include examining the factors that influence the management, planning and design of urban wild ecosystems. In this case, it is important to understand what current social-ecological and socio-cultural factors determine the way urban wild spaces are governed. From a different perspective, experts find it important to examine what type of interventions, and more broadly, laws and regulations, could increase nature connectedness through diverse experiences, improve social-ecological capabilities, and deliver just outcomes. These research questions highlight links between biodiversity, climate change and resilience, but also links between accessibility, health, inclusivity and justice. They also connect to a fundamental priority which is to consider the ethical values that currently drive and should drive the governance of urban wild ecosystems. These sites are, by some, regarded as living laboratories, with the capacity to show how urban ecosystems may thrive in an uncertain future with biodiversity loss and climate change impacts. Finally, identifying and prioritising indicators or variables for measuring the different aspects of urban wild spaces was important to provide informed decision-making.

## 3.3. Prioritising research questions for urban novel ecosystems research and practice

An important element of this research is to assist urban researchers, planners and practitioners with a set of research questions which we have collated into 65 questions drawn from the survey and interview data. Since the utility of this may not be clear or useful, especially to policy-makers, researchers, and research funding agencies who require tangible priorities and therefore measures to compare them to, we have combined and simplified the totality of questions into 21 questions or research areas and asked our participants to rank them (Table 2). They were ranked by the experts ( $n=21$ ), from those considered to be an essential priority to the lowest priority for research. During this process, most of the experts expressed difficulty in ranking the questions as they were all considered critical for understanding these spaces. The difficulty in ranking is due to the interconnectedness amongst the themes as well as the interdisciplinary background of participants. Nonetheless, the driving effort of this study is to offer priorities for policy, practice and research to focus on the most urgent needs for progressing the science of novel ecosystems in urban areas.

Three priorities were flagged as essential. From an ecological perspective, it is viewed as essential to understand the biodiversity of these spaces. Focused on people's perceptions and attitudes, it is of essential importance to investigate the landscape elements that influence changes in value and perceptions of urban wild spaces and their effect on how people interact with them. Finally, it was found critical to understand the factors that influence decision-making regarding urban novel ecosystems. These top priorities are explored below, focusing and reflecting on why they were considered the most urgent by the participants. In this section, we present the three research questions that received the most frequent responses. Table 2 shows all research questions and the scores they received.

### 3.3.1. What biodiversity do urban wild ecosystems support?

Identifying species, and surveying their quantities and interactions was considered an essential research priority. Participants express that insufficient research, underpinned by inadequate funding into wildlife in urban novel ecosystems was hindering our capacity to understand these spaces and inform decisions that could otherwise transform these sites without even knowing what species they were harbouring. The interviewed experts considered that because of their negligible or less intense management regimes in comparison to managed green spaces, as well as the surrounding managed rural/agricultural lands, urban wild ecosystems appear to be some of the last refuges for urban biodiversity. Knowing what biological diversity is present in these sites will provide a critical baseline 'to move forward... [that is] frame actions, support research, and to properly communicate the importance of urban wild spaces to the wider public' (1018). Understanding the biodiversity of these sites is also prioritised because it suggests a non-utilitarian lens to research and practice, focusing on the diversity of nonhuman lives inhabiting novel ecosystems. Additionally, it is broad enough to encompass other lines of enquiry, such as species composition, and the role of these ecosystems in urban ecological connectivity and function.

### 3.3.2. What are the landscape elements that influence changes in value and perceptions of urban wild ecosystems and their effect on how people interact with them?

This question is essential as it is deeply linked to the way we value these spaces which affects our attitudes and responses towards them and consequently, how policies and strategies are developed. The tendency with wild ecosystems is to view them as weedy and invasive, causing for example feelings of ambivalence (Jorgensen & Tylecote, 2007) due to the contradictory meaning these spaces elicit, such as freedom and death simultaneously (Koole & Van den Berg, 2005). Understanding better the perception of the characteristics of these wild territories can shed light as to why and how we can be comfortable and allow more spontaneous colonisation and newer diversities of species to reside amongst us. Relationships between landscape elements and people's perceptions can uncover entrenched biases (e.g. associations between dereliction and negative valuations) (Brun et al., 2018; Mathey et al., 2018). Understanding these biases can guide alternative directions and strategies that add cultural and ecological value to these spaces without losing the wild, emerging nature of these urban ecosystems.

### 3.3.3. What factors should influence the management, planning and design of urban wild ecosystems?

This question is prioritised because of the broader impact it can have in influencing policy outcomes. Factors considered important are people's perceptions and including different voices to explore why they are or are not used, and how these spaces are used. Informing management will also require ecological baselines to plan for biodiversity and will need socio-economic data to better understand, for example, where there is a deficit in green spaces and how novel ecosystems can improve green space accessibility. Previous studies suggest that improving accessibility on a site and adopting well-intentioned management practices with little understanding of the ecology of the site can result in sharp declines in biodiversity (Filibeck et al., 2016). Thus, understanding the social-ecological dynamics that lead to higher biodiversity values whilst improving accessibility through better management approaches is fundamental.

This broad-ranging question can also include exploring factors such as cost-benefit comparisons to understand how costs and resources associated with different management regimes across different urban ecosystem types, influence biodiversity, health, wellbeing and other outcomes that are relevant to local communities. An important aspect that has been threaded throughout this process has been the importance of finding ways in which planning and design interventions in and of wild ecosystems need to consider the self-organising, self-sustaining capacities of the species that inhabit these spaces. Taking this into account suggests that less intense or gentle management approaches can be a way of retaining the essential characteristics of urban novel ecosystems. These can be understood as cues to care where elements of human presence or intention of care are recognisable in the landscape (Li & Nassauer, 2020; Nassauer, 1995).

## 4. Discussion and recommendations for future research directions

A significant contribution of this study was bringing for the first time interdisciplinary knowledge-holders to discuss urban novel ecosystems, a concept and phenomenon that continues to be highly contested and debated. This work complements other studies (Clement & Standish, 2018; Teixeira & Fernandes, 2019) that highlight gaps in research and governance of novel ecosystems and proposes ways to activate the study, recognition and reevaluation of these often neglected ecosystems. By providing a set of research questions in a systematised way it offers a clearer guide for research and planning of urban novel ecosystems. As such, it complements studies in the pursuit of achieving nature-based and just futures (Bina et al., 2024). Another meaningful contribution of this research is that it brings the voices of not only academics as experts but also those involved in planning and policy-making as well as other means of relating to wild ecosystems, such as through art, gardening, foraging and different forms of experimentation. The participants' diverse disciplinary backgrounds and their experiences in working with novel ecosystems and the people who interact with them have highlighted the complex perceptions, values and ways of connecting with wild ecosystems that present challenges but also opportunities for advancing our knowledge of these spaces.

Although this study has a geographical bias, with most participants coming from Europe and the USA, it shows similar results to other studies that emphasise the capacity of these wild landscapes to support conservation efforts, address climate change impacts and risks, and offer refuges for people and nature to benefit and co-exist (Rupprecht, 2017b). For example, the city of Berlin has been leading the way, with a long history of research in these spaces (Kowarik, 2023). Similar studies have also shown the potential of vacant lots to hold ecological value (Anderson & Minor, 2019; Kremer et al., 2013), support biodiversity (Bonthoux et al., 2014), and threatened species in peri-urban Melbourne, Australia (MacLagan et al., 2018). These have been limited in geographic scope and have had little impact on urban policy and planning. Searching for answers to the questions posed in this study will be a stimulating challenge for researchers, policy-makers, planners, designers and local communities, particularly in cities where urban novel ecosystems are overlooked and neglected in research and planning. Important to highlight is that the questions presented as priorities were based on the knowledge-holders' experience and judgement, but these questions might not be important for urban researchers, planners and policy-makers in other geographies, and looking into other questions might be crucial in their localities. Resources, capacities and intent will affect the areas of research that will be prioritised. For example, in the ranking exercise, questions related to the ethical and justice dimensions of novel ecosystems were not deemed as essential to explore, but in other regions and for other knowledge-holders these issues will be considered essential.

Most of the experts frequently regarded these ecosystems as spaces with the capacity to contribute to our grand societal challenges. Through the experts' work and experience, they could see potential in these wild ecosystems for achieving climate resilience, providing alternative habitats for biodiversity, and delivering critical ecosystem services, in particular for underserved and marginalised communities. Many of our participants' reflections focused as well on the importance of these ecosystems as place-making spaces. Their nature of informality, wildness and marginality offers many city inhabitants refuge from the overly managed and regulated character of parks, reserves and other similar green spaces (Gandy, 2016, 2022). In contrast, wild ecosystems present themselves as safe refuges for experimentation, for testing out communing practices, such as gardening and art, that allow for richer expressions of more-than-human relations and encourage social-ecological stewardship (Kennedy et al., 2023; Rupprecht, 2017b). As presented through one of the research questions, it is fundamental that in recognising the value of these spaces, they are also valued and respected in their current form. As living urban landscapes they offer insights into their capacities to respond to anthropogenic changes (Gobster, 2011). Their informality, temporality, and wildness are part of what makes them valuable, so finding ways of protecting them without imposing regulations and mechanisms that will change their nature, is critical. Additionally, while this study solely focused on urban ecosystems within urban contexts, extending these approaches to the broader landscapes, such as agricultural, rural and coastal environments, can provide new understandings of, for example, relationships between novel ecosystems and cultural landscapes (Clement, 2020).

We recommend these areas for research be part of cities' transformative agendas in which urban novel ecosystems offer new

possibilities for climate experimentation and biodiversity conservation now and into the future. However, to do so, it is important to clarify in which ways these questions can be investigated. As such, in the following section, we provide a set of recommendations on how to progress the research questions set out in this study.

#### 4.1. *Examine the research priorities through different tools, techniques and ways of measuring*

How we design and delve into these research questions can take many forms and understandings. For one, bringing inter and transdisciplinary lenses will be essential. This study has shown that bringing together expertise, knowledge and experiences from different backgrounds can produce richer understandings and diverse pathways for improving our knowledge of urban novel ecosystems. It was recognised by the participants that many of the proposed questions are interdependent. As such, sets of related questions can be grouped to develop a series of indicators that can provide an effective means of collecting interrelated data. For example, ecological connectivity, biodiversity and ecosystem function can be paired together to understand multi-scalar processes, multifunctionality and requirements of urban wild spaces. Similarly, understanding what landscape elements influence perceptions and behaviour, will also feed into questions of what design and planning strategies can be tested to improve human nature connectedness and foster new ways of valuing these spaces. Individual or sets of questions can also be approached using forecasting methodologies. These can be foregrounded through co-participation methods involving local stakeholders who live in proximity to and/or interact with their local wild spaces. These could then be validated through expert input, expanding the number, geographical location, and background of experts used in this study. Bringing community scientists to explore these questions would be a way to expand and enhance data collection and streamline decision-making. Engaging and training individuals with different backgrounds, degrees of knowledge and experience to capture data is at the core of citizen or community science (Jorgensen & Jorgensen, 2021). Community science is a widely used approach that is in principle democratic and inclusive by doing science through collaborative processes between communities and scientists and can trigger environmental citizenship (Jorgensen & Jorgensen, 2021). Paired with technology, such as extreme citizen science or community-based monitoring, community science not only has the potential to improve our understanding of novel ecosystems through data collection but also encourage social-ecological stewardship of wild spaces equitably.

#### 4.2. *Bring multiple voices to deepen our understanding of urban novel ecosystems*

This study used an expert-based knowledge-gathering approach to understanding urban novel ecosystems and present a set of questions that can guide future research. This is, however, not the only means of gathering knowledge and we encourage the implementation of other methodologies and methods to explore the needs and priorities that different groups, in varying geographical locations, and at multiple scales, will find important from their understandings. This study offers a template to prioritise research, but also to stimulate a conversation about what is required for research and practice, and hopefully adapt and challenge these priorities towards other needs and ways of knowing. For example, using co-design, co-participatory and co-creation methodologies with local communities can be a means for testing these expert priorities against the needs and views of local communities. Participatory decision-making processes can spark creativity and anticipatory thinking when seeking system transformation for complex problems (Jones, 2018). This creativity and anticipation can be found within collaborative design methods employed such as game-based approaches (Lennon et al., 2016) and scenario envisioning (Jones, 2018). Furthermore, it is the inclusion of communities with highly different interests which can ultimately strengthen the social valuations of ecosystems (Asah & Blahna, 2019). Research of urban novel ecosystems into socio-cultural interactions suggests that they play a significant role in how they are perceived and intervened by the public and how they can potentially be valued in terms of justice (Pineda-Pinto et al., 2023), sense of wonder (Marris, 2021), health and well-being (Cheesbrough et al., 2019; Sivak et al., 2021), social cohesion (Vega et al., 2021), and how they can inform urban planning and management in cities (Kim et al., 2018; Rupprecht, 2017a). However, challenges and tensions remain. There is a need to address and mediate human-nonhuman tensions and conflicts that arise in these spaces. Suggestions to address this and improve acceptability and more-than-human co-existence include understanding residents' preferences (Rupprecht, 2017b). Understanding the coupling of ecosystem services and disservices in these landscapes can also lead to better decision-making by providing knowledge to enhance and restore desirable services and mitigate undesirable ones (Vaz et al., 2017). Answering and gaining knowledge through these questions will influence processes of imagining nature-based futures (Bina et al., 2024) and in turn have implications in the design and development of for example, abandoned land containing novel ecosystems.

As is the nature of the Delphi or other similar expert-based approaches, it fails to include other voices and perspectives that are also vital in thinking, engaging and working when exploring solutions and pathways to complex problems. Encouraging research and practice to be guided by Indigenous perspectives would not only enhance but also challenge the ways we view, talk about and intervene in urban wild spaces. Indigenous care for Country, healing practices and relationships with so-called 'invasive' or alien species can differ drastically from traditional conservation ecology (Reo & Ogden, 2018). Hernandez (Hernandez, 2022) argues that under the dominant Western conservation lens, banana trees in the Latin American region are seen as an invasive species. However, from her Indigenous positioning, banana trees are regarded as displaced relatives and the relationship to them is of kinship (Hernandez, 2022). We are reminded as well, that in Australia there are a multiplicity of Indigenous views on invasives species and ecology and this should reflect this diversity and caring for Country practices (Barbour & Schlesinger, 2012). Future studies can work with Indigenous knowledge systems that explore relations to novel landscapes and species deemed as invasive or 'out of place' and find ways on how Indigenous and non-indigenous ways of knowing can work together to collectively find ways to care for these landscapes. Ideas like multispecies thinking, also foregrounded in traditional ways of caring for the landscape (Sydney Environment Institute,

2023), decentres the human-centred, colonial ways of planning our cities (Porter et al., 2020) and can help us navigate through the complex narratives behind novel ecosystems.

## 5. Conclusion

This paper presented insights from a modified Delphi expert-based approach which consisted of surveying, conducting semi-structured interviews, and a ranking exercise with a panel of knowledge-holders that includes researchers, practitioners, and policy/decision-makers with knowledge in and of urban novel ecosystems. This process explored different understandings of urban novel ecosystems through diverse participant experiences and laid the ground to set out critical areas of research for better understanding the role that novel ecosystems play in cities, from an ecological, perceptions and planning lens. Exploring these questions can enable informed decision-making and imaginably provide new insights into how we value, manage and study urban novel ecosystems now and in the future. The lack of funding in this research and practice space was evidenced by the participants. Underlying all these recommendations is the need to increase resources to study the potential of anthropogenic ecosystems.

While research on novel ecosystems is growing in knowledge, urban novel ecosystems are less studied and as such present opportunities for understanding their contributions and potential for addressing grand societal challenges such as human-nature relations, building climate resilience, increasing and protecting repositories for biodiversity, and delivering critical ecosystem services. Of unique interest, urban novel ecosystems may help urban communities to reflect on the deeper meanings that these spaces represent in daily lives. As spaces that are the products of continuous use, misuse, and neglect, they manifest an element of hope, regeneration, resilience, and healing. This may offer practitioners and communities new opportunities to attend to values and understandings that can turn social-ecological vulnerabilities into social-ecological opportunities.

## CRediT authorship contribution statement

**Natalia Rodriguez Castañeda:** Writing – review & editing, Validation, Formal analysis, Data curation. **Fiona Nulty:** Writing – review & editing, Validation, Formal analysis, Data curation. **Maíread O'Donnell:** Writing – review & editing, Validation, Formal analysis, Data curation. **Clair Cooper:** Writing – review & editing, Validation, Formal analysis, Data curation. **Marcus Collier:** Writing – review & editing, Writing – original draft, Validation, Supervision, Funding acquisition, Formal analysis. **Melissa Pineda Pinto:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Formal analysis, Conceptualization.

## Declaration of Competing Interest

The authors declare no conflict of interest.

## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.futures.2024.103487](https://doi.org/10.1016/j.futures.2024.103487).

## Data availability

I have shared the link to my data in the Attach files step.

## References

- Ahern, J. (2016). Novel urban ecosystems: Concepts, definitions and a strategy to support urban sustainability and resilience [Report]. *Landscape Architecture Frontiers*, 4, 10+. (<https://link.gale.com/apps/doc/A459715410/AONE?u=anon-d1ac460a&sid=googleScholar&xid=f58c1ced>).
- Anderson, E. C., & Minor, E. S. (2019). Assessing social and biophysical drivers of spontaneous plant diversity and structure in urban vacant lots. *Science of the Total Environment*, 653, 1272–1281. <https://doi.org/10.1016/j.scitotenv.2018.11.006>
- Aronson, J., Murcia, C., Kattan, G. H., Moreno-Mateos, D., Dixon, K., & Simberloff, D. (2014). The road to confusion is paved with novel ecosystem labels: a reply to Hobbs <em>et al.</em>. *Trends in Ecology Evolution*, 29(12), 646–647. <https://doi.org/10.1016/j.tree.2014.09.011>
- Asah, S. T., & Blahna, D. J. (2019). Involving stakeholders' knowledge in co-designing social valuations of biodiversity and ecosystem services: implications for decision-making. *Ecosystems*, 23(2), 324–337. <https://doi.org/10.1007/s10021-019-00405-6>
- Backstrom, A. C., Garrard, G. E., Hobbs, R. J., & Bekessy, S. A. (2018). Grappling with the social dimensions of novel ecosystems. *Frontiers in Ecology and the Environment*, 16(2), 109–117. <https://doi.org/10.1002/fee.1769>
- Barbour, W., & Schlesinger, C. (2012). Who's the boss? Post-colonialism, ecological research and conservation management on Australian Indigenous lands. *Ecological Management Restoration*, 13(1), 36–41. <https://doi.org/10.1111/j.1442-8903.2011.00632.x>
- Beiderbeck, D., Frevel, N., von der Gracht, H. A., Schmidt, S. L., & Schweitzer, V. M. (2021). Preparing, conducting, and analyzing Delphi surveys: Cross-disciplinary practices, new directions, and advancements. *MethodsX*, 8, Article 101401. <https://doi.org/10.1016/j.mex.2021.101401>
- Bina, O., Baptista, M. D., Pereira, M. M., Inch, A., Falanga, R., Alegria, V., Caquimbo-Salazar, S., Duarte, D. H. S., Mercado, G., Valenta, A. T., Vásquez, A., & Verellen, T. (2024). Exploring desired urban futures: the transformative potential of a nature-based approach. *Futures*, 159. <https://doi.org/10.1016/j.futures.2024.103362>
- Bonthoux, S., Brun, M., Di Pietro, F., Greulich, S., & Bouché-Pillon, S. (2014). How can wastelands promote biodiversity in cities? A review. *Landscape and Urban Planning*, 132, 79–88.

- Brady, S. R. (2015). Utilizing and adapting the delphi method for use in qualitative research. *International Journal of Qualitative Methods*, 14(5). <https://doi.org/10.1177/1609406915621381>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp0630a>
- Bridgewater, P., Higgs, E. S., Hobbs, R. J., & Jackson, S. T. (2011). Engaging with novel ecosystems, 423–423 *Frontiers in Ecology and the Environment*, 9(8). <https://doi.org/10.1890/1540-9295-9.8.423>
- Brun, M., Di Pietro, F., & Bonhoux, S. (2018). Residents' perceptions and valuations of urban wastelands are influenced by vegetation structure. *Urban Forestry Urban Greening*, 29, 393–403. <https://doi.org/10.1016/j.ufug.2017.01.005>
- Cheesbrough, A. E., Garvin, T., & Nykiforuk, C. I. J. (2019). Everyday wild: Urban natural areas, health, and well-being. *Health Place*, 56, 43–52. <https://doi.org/10.1016/j.healthplace.2019.01.005>
- Clark, T., Foster, L., Bryman, A., & Sloan, L. (2021). *Bryman's Social Research Methods*. Oxford University Press.
- Clement, S. (2020). *Governing the Anthropocene: Novel Ecosystems, Transformation and Environmental Policy*. Palgrave Macmillan.
- Clement, S., & Standish, R. J. (2018). Novel ecosystems: Governance and conservation in the age of the Anthropocene. *Journal of Environmental Management*, 208, 36–45. <https://doi.org/10.1016/j.jenvman.2017.12.013>
- Collier, M. (2015). Novel ecosystems and social-ecological resilience. 30(8), 1363–1369.
- Collier, M. J., Nedović-Budić, Z., Aerts, J., Connop, S., Foley, D., Foley, K., Newport, D., McQuaid, S., Slaev, A., & Verburg, P. (2013). Transitioning to resilience and sustainability in urban communities. *Cities*, 32, S21–S28. <https://doi.org/10.1016/j.cities.2013.03.010>
- DiStefano, C., Shi, D., & Morgan, G. B. (2021). Collapsing categories is often more advantageous than modeling sparse data: investigations in the CFA Framework. *Structural Equation Modeling: A Multidisciplinary Journal*, 28(2), 237–249. <https://doi.org/10.1080/10705511.2020.1803073>
- Draus, P., Haase, D., Napieralski, J., Sparks, A., Qureshi, S., & Roddy, J. (2020). Wastelands, greenways and gentrification: introducing a comparative framework with a focus on Detroit, USA. *Sustainability*, 12(15). <https://doi.org/10.3390/su12156189>
- Drumm, S., Bradley, C., & Moriarty, F. (2022). More of an art than a science? The development, design and mechanics of the Delphi Technique. *Res Social Adm Pharm*, 18(1), 2230–2236. <https://doi.org/10.1016/j.sapharm.2021.06.027>
- Erle, C.E., & Navin, R. (2008). Putting people in the map: anthropogenic biomes of the world.
- Filibeck, G., Petrella, P., & Cornellini, P. (2016). All ecosystems look messy, but some more so than others: A case-study on the management and acceptance of Mediterranean urban grasslands. *Urban Forestry Urban Greening*, 15, 32–39. <https://doi.org/10.1016/j.ufug.2015.11.005>
- Flood, S., Rogan, F., Revéz, A., McGookin, C., O'Dwyer, B., Harris, C., Dunphy, N., Byrne, E., Gallachóir, B.Ó., Bolger, P., Boyle, E., Glynn, J., Barry, J., Ellis, G., & Mullally, G. (2023). Imagining climate resilient futures: A layered Delphi panel approach. *Futures*, 147. <https://doi.org/10.1016/j.futures.2023.103100>
- Gandy, M. (2016). Unintentional landscapes. *Landscape Research*, 41(4), 433–440. <https://doi.org/10.1080/01426397.2016.1156069>
- Gandy, M. (2022). Ghosts and monsters: Reconstructing nature on the site of the Berlin Wall. *Transactions of the Institute of British Geographers*, 47(4), 1120–1136. <https://doi.org/10.1111/tran.12562>
- Ganko, A. (2020). What a waste? Reflexion on social use of wastelands during the pandemic. *Journal of Education, Culture Society*, 11(2), 147–154.
- Gobster, P. H. (2011). Urban Wildscapes. In In. A. J. a R. Keenan (Ed.), *Appreciating Urban Wildscapes: Towards a Natural History of Unnatural Places*. Routledge.
- Grace, M., Balzan, M., Collier, M., Geneletti, D., Tomaskinova, J., Abela, R., Borg, D., Buhagiar, G., Camilleri, L., Cardona, M., Cassar, N., Cassar, R., Cattafi, I., Cauchi, D., Galea, C., La Rosa, D., Malekkidou, E., Masini, M., Portelli, P., & Dicks, L. V. (2021). Priority knowledge needs for implementing nature-based solutions in the Mediterranean islands. *Environmental Science Policy*, 116, 56–68. <https://doi.org/10.1016/j.envsci.2020.10.003>
- Grimbeek, P., Bryer, F., Beamish, W., & D'Netto, M. (2005). Use of data collapsing strategies to identify latent variables in CHP questionnaire data. *Proceedings of 3rd International Conference on Cognition, Language, and Special Education*. Brisbane: Griffith Research Online.
- Habibi, A., Sarafrazi, A., & Izadyar, S. (2014). *Delphi Technique Theoretical Framework in Qualitative Research*.
- Hannah, D. R., & Lautsch, B. A. (2011). Counting in qualitative research: Why to conduct it, when to avoid it, and when to closet it. *Journal of Management Inquiry*, 20(1), 14–22.
- Hernandez, J. (2022). *Fresh Banana Leaves: Healing Indigenous Landscapes Through Indigenous Science*. North Atlantic Books.
- Hobbs, R.J., Arico, S., Aronson, J., Baron, J.S., Bridgewater, P., Cramer, V.A., Epstein, P.R., Ewel, J.J., Klink, C.A., Lugo, A.E., Norton, D., Ojima, D., Richardson, D.M., Sanderson, E.W., Valladares, F., Vilà, M., Zamora, R., & Zobel, M. (2006). *Novel Ecosystems: Theoretical and Management Aspects of the New Ecological World Order* (Vol. 15).
- Hobbs, R. J., Higgs, E. S., & Hall, C. M. (2013). Defining novel ecosystems. *Novel Ecosystems*, 58–60. <https://doi.org/10.1002/9781118354186.ch6>
- Hsu, C.-C., & Sandford, B. A. (2007). *The Delphi Technique: Making Sense of Consensus*. <https://doi.org/10.7275/pd29-th90>
- Jones, P. (2018). Contexts of Co-creation: Designing with System Stakeholders. In In. P. Jones, & K. Kijima (Eds.), *Systemic Design: Theory, Methods, and Practice* (pp. 3–52). Springer Japan. [https://doi.org/10.1007/978-4-431-55639-8\\_1](https://doi.org/10.1007/978-4-431-55639-8_1)
- Jorgensen, A., & Keenan, R. (2012). *Urban Wildscapes*. Routledge. <https://doi.org/10.4324/9780203807545>
- Jorgensen, A., & Tylecote, M. (2007). Ambivalent landscapes - Wilderness in the Urban interstices, 32(4), 443–462.
- Jorgensen, F. A., & Jorgensen, D. (2021). Citizen science for environmental citizenship. *Conserv Biol*, 35(4), 1344–1347. <https://doi.org/10.1111/cobi.13649>
- Kennedy, C. (2022). Ruderal resilience: applying a ruderal lens to advance multispecies urbanism and social-ecological systems theory. *Frontiers in Built Environment*, 8. <https://doi.org/10.3389/fbuil.2022.769357>
- Kennedy, C., Irons, E., & Watts, P. L. (2023). Ecological art in cities: exploring the potential for art to promote and advance nature-based solutions. In In. T. McPhearson, N. Kabisch, N. Frantzeskaki, C. Kennedy, E. Irons, & P. Lea Watts (Eds.), *Nature-Based Solutions for Cities*. pp. 316–339). Edward Elgar Publishing. <https://doi.org/10.4337/9781800376762>, 10.4337/9781800376762.00026.
- Kim, M., Rupprecht, C., & Furuya, K. (2018). Residents' perception of informal green space—a case study of Ichikawa City, Japan. *Land*, 7(3). <https://doi.org/10.3390/land7030102>
- Koole, S. L., & Van den Berg, A. E. (2005). Lost in the wilderness: terror management, action orientation, and nature evaluation. *Journal of Personality and Social Psychology*, 88(6), 1014–1028. <https://doi.org/10.1037/0022-3514.88.6.1014>
- Kowarik, I. (2023). Urban biodiversity, ecosystems and the city. Insights from 50 years of the Berlin School of urban ecology. *Landscape and Urban Planning*, 240, Article 104877. <https://doi.org/10.1016/j.landurbplan.2023.104877>
- Kremer, P., Hamstead, Z. A., & McPhearson, T. (2013). A social-ecological assessment of vacant lots in New York City. *Landscape and Urban Planning*, 120, 218–233. <https://doi.org/10.1016/j.landurbplan.2013.05.003>
- Lee, R. J., & Newman, G. (2021). The relationship between vacant properties and neighborhood gentrification. *Land Use Policy*, 101. <https://doi.org/10.1016/j.landusepol.2020.105185>
- Lennon, M., Scott, M., Collier, M., & Foley, K. (2016). Developing green infrastructure 'thinking': devising and applying an interactive group-based methodology for practitioners. *Journal of Environmental Planning and Management*, 59(5), 843–865. <https://doi.org/10.1080/09640568.2015.1042152>
- Li, J., & Nassauer, J. I. (2020). Cues to care: A systematic analytical review. *Landscape and Urban Planning*, 201. <https://doi.org/10.1016/j.landurbplan.2020.103821>
- MacLagan, S. J., Coates, T., & Ritchie, E. G. (2018). Don't judge habitat on its novelty: Assessing the value of novel habitats for an endangered mammal in a peri-urban landscape. *Biological Conservation*, 223, 11–18. <https://doi.org/10.1016/j.biocon.2018.04.022>
- Marín, V. H., & Finlayson, C. M. (2019). Social-ecological Complexities and Novel Ecosystems. *Social-Ecological Systems of Latin America: Complexities and Challenges*, 149–158. [https://doi.org/10.1007/978-3-030-28452-7\\_9](https://doi.org/10.1007/978-3-030-28452-7_9)
- Marris, E. a (2021). Wild souls. *Freedom and Flourishing in the Non-Human World*, In, 0–1.
- Mathey, J., Arndt, T., Banse, J., & Rink, D. (2018). Public perception of spontaneous vegetation on brownfields in urban areas—Results from surveys in Dresden and Leipzig (Germany). *Urban Forestry Urban Greening*, 29, 384–392. <https://doi.org/10.1016/j.ufug.2016.10.007>
- Maxey, D., & Kezar, A. (2016). Leveraging the Delphi technique to enrich knowledge and engage educational policy problems. *Educational Policy*, 30(7), 1042–1070. <https://doi.org/10.1177/0895904815586856>

- Morse, N. B., Pellissier, P. A., Cianciola, E. N., Brereton, R. L., Sullivan, M. M., Shonka, N. K., Wheeler, T. B., & McDowell, W. H. (2014). Novel ecosystems in the Anthropocene: a revision of the novel ecosystem concept for pragmatic applications. Article 12. *Ecology and Society*, 19(2). <https://doi.org/10.5751/ES-06192-190212>
- Mukherjee, N., Zabala, A., Hugel, J., Nyumba, T. O., Adem Esmail, B., Sutherland, W. J., & Everard, M. (2018). Comparison of techniques for eliciting views and judgements in decision-making. *Methods in Ecology and Evolution*, 9(1), 54–63. <https://doi.org/10.1111/2041-210x.12940>
- Murcia, C., Aronson, J., Kattan, G. H., Moreno-Mateos, D., Dixon, K., & Simberloff, D. (2014). A critique of the ‘novel ecosystem’ concept. *Trends in Ecology Evolution*, 29(10), 548–553. <https://doi.org/10.1016/j.tree.2014.07.006>
- Nassauer, J. I. (1995). Messy ecosystems, orderly frames. *Landscape Journal*, 14(2). <https://www.jstor.org/stable/43324192>.
- Perring, M. P., Standish, R. J., & Hobbs, R. J. (2013). Incorporating novelty and novel ecosystems into restoration planning and practice in the 21st century. *Ecological Processes*, 2(1), 18. <https://doi.org/10.1186/2192-1709-2-18>
- Pineda-Pinto, M., Herreros-Cantis, P., McPhearson, T., Frantzeskaki, N., Wang, J., & Zhou, W. (2021). Examining ecological justice within the social-ecological-technological system of New York City, USA. *Landscape and Urban Planning*, 215, Article 104228. <https://doi.org/10.1016/j.landurbplan.2021.104228>
- Pineda-Pinto, M., Kennedy, C., Collier, M., Cooper, C., O'Donnell, M., Nulty, F., & Castañeda, N. R. (2023). Finding justice in wild, novel ecosystems: A review through a multispecies lens. *Urban Forestry Urban Greening*, 83. <https://doi.org/10.1016/j.ufug.2023.127902>
- Porter, L., Hurst, J., & Grandinetti, T. (2020). The politics of greening uncaded lands in the settler city. *Australian Geographer*, 51(2), 221–238. <https://doi.org/10.1080/00049182.2020.1740388>
- Reo, N. J., & Ogden, L. A. (2018). Anishnaabe Aki: an indigenous perspective on the global threat of invasive species. *Sustainability Science*, 13(5), 1443–1452. <https://doi.org/10.1007/s11625-018-0571-4>
- Rupprecht, C. (2017a). Informal urban green space: residents' perception, use, and management preferences across four major Japanese shrinking cities. *Land*, 6(3). <https://doi.org/10.3390/land6030059>
- Rupprecht, C. (2017b). Ready for more-than-human? Measuring urban residents' willingness to coexist with animals. *Fennia - International Journal of Geography*, 195(2), 142–160. <https://doi.org/10.111143/fennia.64182>
- Rupprecht, C., & Byrne, J. A. (2014). Informal urban greenspace: A typology and trilingual systematic review of its role for urban residents and trends in the literature. *Urban Forestry Urban Greening*, 13(4), 597–611. <https://doi.org/10.1016/j.ufug.2014.09.002>
- Seastedt, T. R., Hobbs, R. J., & Suding, K. N. (2008). Management of novel ecosystems: are novel approaches required? *Frontiers in Ecology and the Environment*, 6(10), 547–553. <https://doi.org/10.1890/070046>
- Sivak, C. J., Pearson, A. L., & Hurlburt, P. (2021). Effects of vacant lots on human health: A systematic review of the evidence. *Landscape and Urban Planning*, 208. <https://doi.org/10.1016/j.landurbplan.2020.104020>
- Sydney Environment Institute. (2023). The Sydney Environment Podcast Series In *Other-wise: Indigenous philosophies and practices of multispecies justice*. (<https://www.sydney.edu.au/sydney-environment-institute/events/2023/other-wise-indigenous-philosophies-and-practices-of-multispecies-justice.html>).
- Teixeira, C. P., & Fernandes, C. O. (2019). Novel ecosystems: a review of the concept in non-urban and urban contexts. *Landscape Ecology*, 35(1), 23–39. <https://doi.org/10.1007/s10980-019-00934-4>
- Threlfall, C. G., & Kendal, D. (2018). The distinct ecological and social roles that wild spaces play in urban ecosystems. *Urban Forestry Urban Greening*, 29, 348–356. <https://doi.org/10.1016/j.ufug.2017.05.012>
- Turoff, M., & Linstone, H. A. (Eds.). (1975). *Delphi Method - Techniques and Applications*. Addison-Wesley.
- Vaz, A. S., Kueffer, C., Kull, C. A., Richardson, D. M., Vicente, J. R., Kühn, I., Schröter, M., Hauck, J., Bonn, A., & Honrado, J. P. (2017). Integrating ecosystem services and disservices: insights from plant invasions. *Ecosystem Services*, 23, 94–107. <https://doi.org/10.1016/j.ecoser.2016.11.017>
- Vega, K. A., Schlöpfer-Miller, J., & Kueffer, C. (2021). Discovering the wild side of urban plants through public engagement. *Plants, People, Planet*, 3(4), 389–401. <https://doi.org/10.1002/ppp3.10191>
- von der Gracht, H. A. (2012). Consensus measurement in Delphi studies. *Technological Forecasting and Social Change*, 79(8), 1525–1536. <https://doi.org/10.1016/j.techfore.2012.04.013>
- Wenger-Trayner, E., Fenton-O'Creevy, M., Hutchinson, S., Kubiak, C., & Wenger-Trayner, B. (2015). *Learning in Landscapes of Practice- Boundaries, Identity, and Knowledgeability in Practice-Based Learning* (Eds.). Routledge.
- Williams, J. W., & Jackson, S. T. (2007). Novel climates, no-analog communities, and ecological surprises. *Frontiers in Ecology and the Environment*, 5(9), 475–482.
- Wyborn, C., Davila, F., Pereira, L., Lim, M., Alvarez, I., Henderson, G., Luers, A., Martinez Harms, M. J., Maze, K., Montana, J., Ryan, M., Sandbrook, C., Shaw, R., & Woods, E. (2020). Imagining transformative biodiversity futures. *Nature Sustainability*, 3(9), 670–672. <https://doi.org/10.1038/s41893-020-0587-5>
- Wyborn, C., Montana, J., Kalas, N., Clement, S., Davila, F., Knowles, N., Louder, E., Balan, M., Chambers, J., Christel, L., Forsyth, T., Henderson, G., Izquierdo Tort, S., Lim, M., Martinez-Harms, M. J., Mercon, J., Nuesiri, E., Pereira, L., Pilbeam, V., ... Ryan, M. (2021). An agenda for research and action toward diverse and just futures for life on Earth. *Conserv Biol*, 35(4), 1086–1097. <https://doi.org/10.1111/cobi.13671>
- Zartha Sossa, J. W., Halal, W., & Hernandez Zarta, R. (2019). Delphi method: analysis of rounds, stakeholder and statistical indicators. *Foresight*, 21(5), 525–544. <https://doi.org/10.1108/fs-11-2018-0095>