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RESEARCH ARTICLE

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Developing multiscale and integrative nature–people scenarios using the Nature Futures Framework

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Abstract

1. Scientists have repeatedly argued that transformative, multiscale global scenarios are needed as tools in the quest to halt the decline of biodiversity and achieve sustainability goals.
2. As a first step towards achieving this, the researchers who participated in the scenarios and models expert group of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) entered into an iterative,

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participatory process that led to the development of the Nature Futures Framework (NFF).

3. The NFF is a heuristic tool that captures diverse, positive relationships of humans with nature in the form of a triangle. It can be used both as a boundary object for continuously opening up more plural perspectives in the creation of desirable nature scenarios and as an actionable framework for developing consistent nature scenarios across multiple scales.
4. Here we describe the methods employed to develop the NFF and how it fits into a longer term process to create transformative, multiscale scenarios for nature. We argue that the contribution of the NFF is twofold: (a) its ability to hold a **plurality** of perspectives on what is **desirable**, which enables the development of joint goals and visions and recognizes the possible convergence and synergies of measures to achieve these visions and (b), its **multiscale** functionality for elaborating scenarios and models that can inform decision-making at relevant levels, making it applicable across specific places and perspectives on nature.
5. If humanity is to achieve its goal of a more sustainable and prosperous future rooted in a flourishing nature, it is critical to open up a space for more plural perspectives of human–nature relationships. As the global community sets out to develop new goals for biodiversity, the NFF can be used as a navigation tool helping to make diverse, desirable futures possible.

KEYWORDS

biodiversity, futures, IPBES, models, nature, scenarios, values

1 | INTRODUCTION

The rapid decline in the state of nature and its clear links to the prosperity of human societies has led scientists to argue that transformative change is required in how societies relate to nature. The first Global Assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the recent special report on Global Warming of 1.5°C of the Intergovernmental Panel on Climate Change (IPCC) both argue that a sustainable world cannot be achieved without transformative systemic change of our societies (IPBES, 2019; IPCC, 2018). Achieving such a change requires identifying visions, pathways and plans that can help people navigate away from undesirable futures and towards desirable ones (Balvanera et al., 2017; Bennett et al., 2016; Peterson et al., 2018). The urgency to reframe the future of human societies' relationships with nature has become even clearer since the outbreak of the Covid-19 pandemic, which is sure to enter the global negotiation agendas for the next biodiversity and climate change targets that will take place in 2021. Decisions on how to catalyse transformative change can be supported by the co-production of visions, scenarios and pathways that are collectively and transparently developed and are made accessible to all interested stakeholders (Pereira, Asrar, et al., 2019). New types of globally relevant scenarios and futures are urgently needed that not only provide an orientation of what diverse possibilities might be achievable, but also to catalyse the movement towards these more desirable futures for people and the planet, in all their plurality (Luederitz, Abson, Audet, & Lang, 2017).

In this paper, we address the question of how a new set of scenarios that respond to these needs can be developed. We outline the systematic steps to develop such scenarios that have been made by a group of experts who participated in the IPBES scenarios and models expert group, and we explain the methodology of each element of the process in detail to illustrate how the process differs from the development of previous global environmental scenarios. A key outcome of the process thus far has been the creation of the Nature Futures Framework (NFF), a heuristic tool based on the diverse, positive relationships that humans have with nature, whilst at the same time offering a structure for consistency in the scenarios and models that use it. The NFF enables the co-production of novel scenarios that incorporate diverse interventions towards positive future trajectories for nature and nature's contributions to people. In our discussion, we analyse the contribution of the NFF both as a boundary object to open up more plural perspectives in the creation of nature scenarios and as an actionable framework for developing consistent nature scenarios across multiple scales and levels, whilst enabling this plurality to flourish.

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We conclude with a call to arms for the research community to mobilize and help in moving this agenda forward. We see a broad sweep of the research community interested in the future of nature and its contributions to people as the main audience for this paper. By describing here the background, methodological process and rationale underpinning the NFF, we hope that it will inspire other researchers—ranging from those interested in participatory co-production processes with local communities through to global integrated assessment modellers—to integrate the NFF into their own activities. We set out specifics for how we envision this joint venture could be undertaken in the discussion.

1.1 | New scenarios for nature

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services was established in 2012 by 94 member states of the United Nations to become the leading intergovernmental body for assessing the state of nature and nature's contributions to people (NCP), as well as options for action. The IPBES conceptual framework illustrates that the ways that nature, biodiversity and ecosystem services are conceived and valued vary across cultures and societies (Díaz et al., 2015). People ascribe different types of values to nature, and its contributions to a good quality of life are often perceived and conceptualized by people in different and sometimes conflicting ways (e.g. as the environment, Mother Earth, natural resources, natural capital from which people derive ecosystem services, our biological community etc.; IPBES, 2015). Furthermore, people ascribe multiple values to the same natural entity (e.g. a landscape can simultaneously be seen as a provider of food and medicine, a good site for mineral exploitation, important for water supply, a habitat for wildlife, a beautiful place or a sacred space; IPBES, 2015). Being able to recognize this plurality and address it in assessments, policies, models and scenarios is a key goal of IPBES.

Scenarios are recognized as powerful tools to examine how different pathways of future human development and policy choices could affect nature and nature's contributions to people (NCP; Ferrier et al., 2016; Harrison et al., 2018; Rosa et al., 2017). However, to date, most scenarios for global environmental assessments have explored impacts of society on nature, such as biodiversity loss, but have not explored the role of nature and related policies in driving development (Ferrier et al., 2016; Millennium Ecosystem Assessment, 2005; Pereira et al., 2010; Saito et al., 2019). Indeed, the variety of connections between people and nature, and how these vary across the world, have mostly been ignored in scenario processes, and the linkages between nature and nature's contributions to people have been underexplored (Cumming et al., 2005; Johnson et al., 2020; Rosa et al., 2017). Furthermore, most existing global assessment scenarios have only been conducted at aggregated global scales, in which local and regional variation, tele-connections and cross-scale dynamics have not been well captured (IPBES, 2016; Obermeister, 2019; Rosa et al., 2017). Addressing issues of power and rationality in how scenarios are framed, and ensuring an equitable inclusion of voices, especially those of the most marginalized to frame matters of concern is another core challenge (Cairns & Wright, 2019). In relation to nature conservation, IPBES have highlighted the particular importance of including indigenous and local knowledge (ILK), which has long been marginalized or invisible in global scenarios and models. It is therefore increasingly clear that there is a need for new global scenarios for nature (Kok et al., 2016; Rosa et al., 2017; Wyborn et al., 2020).

The scenarios that are currently widely used in global environmental assessments are the Shared Socio-Economic pathways (SSPs). The SSPs were developed by the climate change community to help outline potential socio-economic trends that would influence how climate change manifests in the future (O'Neill et al., 2014, 2017). Whilst they have been successful in both the science and policy domain and in unifying different areas of research, the SSPs have limitations in their applicability to biodiversity and nature research. Firstly, they say little about desirable outcomes for nature and its contributions to people, making it difficult to incorporate biodiversity-specific interventions into models (IPBES, 2016; Rosa et al., 2017). This limits their ability to inspire change (Bennett et al., 2016; IPBES, 2016; Pereira, Sitas, Ravera, Jimenez-Aceituno, & Merrie, 2019). Second, these scenarios are expert-led and have not been legitimized through a co-production process in which a plurality of perspectives are included (Duncan et al., 2018; Kok et al., 2016; Tengö et al., 2017). Finally, the SSPs focus on their use only as inputs to a scientific process (O'Neill et al., 2017). However, in global assessments scenarios also act as boundary objects that are used to mobilize action, and as tools for building future literacy amongst stakeholders (Kok et al., 2016; Tengö et al., 2017). These concerns highlight the need for new, participatory nature scenarios that can inform decision-making and inspire action.

Following from the IPBES methodological assessment of scenarios and models of biodiversity and ecosystem services (IPBES, 2016), the former IPBES scenarios and models expert group set out a research strategy to address some of the above concerns and initiated the development of multiscale scenarios for nature based on pluralistic desirable visions for human relationships with nature (Rosa et al., 2017). These scenarios should be produced at and applicable across **multiple scales** through a process that includes a **diversity of stakeholder voices and values**, and explicitly include pathways that enable humanity to meet the **desired** 2050 vision under the Convention on Biological Diversity (CBD) of 'Living in harmony with nature' where 'biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people' (UNEP, 2010: para 11). Central to this process was the research question of how to develop these new scenarios in a way that addresses the gaps identified in other scenarios in order to support the work programme of IPBES. In this paper, we answer this question by documenting the iterative process that was undertaken by the IPBES scenarios and models expert

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group from 2016 to 2019. Presenting methodological approaches in scenario development is important to ensure scientific credibility as well as legitimacy (Sarkki et al., 2014), but it also ensures replicability where others are able to build on and further contribute to the approach, and critique it. In the following section, we present the outputs of the process to date, including a description of the visions, stakeholder feedback and framework development, and also outline the plan for the development of scenarios that can be used by modellers and practitioners.

2 | METHODOLOGICAL APPROACH

There is an emerging agreement that sustainability challenges require new ways of knowledge production and decision-making, including the involvement of actors from outside academia into the research process in order to integrate the best available knowledge, reconcile values and preferences, as well as create ownership for problems and solution options (Laing & Wallis, 2016; Obermeister, 2017). As the development of the new nature scenarios is taking place under the auspices of an intergovernmental science–policy platform, such a transdisciplinary approach was required. However, doing transdisciplinary research is not straightforward and requires a deep level of reflection and learning as well as an openness to change direction in response to the needs of diverse participants (Norström et al., 2020; Pereira, Frantzeskaki, et al., 2019). As such, the methodological approach of the scenario development process needed to navigate this complex reality whilst resulting in a usable outcome.

There is currently a debate as to whether ensuring credibility, relevance and legitimacy are of the utmost importance to policy in assessment processes (Sarkki et al., 2015) or whether applicability, comprehensiveness, timing and accessibility are of more relevance (Dunn & Laing, 2017). At the same time, there are trade-offs and constraints to any science–policy process (Sarkki et al., 2014). Whilst being able to leverage the inclusion, representivity and legitimacy offered by intergovernmental platforms, this can also come with certain constraints, including limited time and funding to undertake specific tasks (see Sarkki et al., 2014), and sometimes a lack of interdisciplinary expertise and other forms of knowledge (Harrison et al., 2018; Obermeister, 2017; Vadrot, Jetzkowitz, & Stringer, 2016; Vadrot, Rankovic, Lapeyre, Aubert, & Laurans, 2018). For the expert group, designing a process that could overcome these constraints, whilst producing diverse multiscale positive scenarios for nature was a key challenge. A first step was to ensure a common language of terms within the research group (Box 1). A second step was the development of core principles. Despite these considerations, the overall approach, especially in terms of including stakeholder voices in the process, was a combination of systematic outreach to a broad diversity of stakeholders across all continents and levels of governance, and using additional opportunities as they occurred in order to reach more voices. This process was still constrained by the limited human and budget resources that were available.

We employed three core principles for the approach: co-production, interactive iteration and pluralism. **Co-production** is increasingly seen as an important process in sustainability science as it enables the harnessing of multiple viewpoints and creates buy-in to a process (Norström et al., 2020). A core aspect of the science–policy interface is the dynamic **interaction** between stakeholders and scientists that **iterates** over time, allowing for learning and readjustments (Priess & Hauck, 2014; Sarkki et al., 2015). Finally, according to the IPBES conceptual framework, a **plurality** of perspectives is core to the platform (Díaz et al., 2015). The subsequent approach was largely informed by the multiple evidence base approach where an enriched picture of understanding serves a starting point for further knowledge generation, triangulation and assessment (Tengö, Brondizio, Elmqvist, Malmer, & Spierenburg, 2014; Tengö et al., 2017).

Next, we outline the iterative process (in the form of phases) and outcomes that resulted at each step, and lay out what is planned to continue to build on the process in the future. This iterative approach is how we went about answering the research question of how to create a new set of scenarios that are diverse, desirable, and multiscale. It has taken time and learning along the way has been a key part of this process, which is also why we seek to document it in this paper. In the discussion section, we situate the findings from this process within the existing literature and critically examine the contribution that the NFF could make in its aim for improved nature scenarios for decision-making in the post 2020 agenda.

2.1 | Iterative phases

The scenario development process consisted of five distinct methodological phases (Figure 1): Phase (i) visioning and storyline development through a participatory workshop (Section 3.1); Phase (ii) elaboration through stakeholder engagement to address gaps in the visions (Section 3.2); Phase (iii) formulation of the NFF based on analysis of the elaborated visions by the expert group (Section 3.3); Phase (iv) further refinement of the NFF through stakeholder engagement (Section 3.4); and finally, Phase (v) consolidation of scenario narratives that can be used by diverse research communities, including modellers (Section 3.5). In the results section, we present the methods that were used as well as the outputs that arose from each of the steps. We discuss the implications of the method and the future development of the NFF scenarios in Section 4.

2.2 | Analysis

At each step in the co-production process, information was documented and recorded. For the analysis of the information captured from the stakeholder engagement exercises (Phases i, ii and iv), an approach similar to the Nominal Group Technique (NGT) was

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BOX 1 Glossary of terms

Drivers—The external factors that cause change in nature, anthropogenic assets, nature's contributions to people and a good quality of life. They include institutions and governance systems and other indirect drivers, and direct drivers (both natural and anthropogenic; IPBES, 2016).

Future wheels—A graphic method similar to a collectively brainstormed mind-map that identifies direct and indirect future consequences or impacts of a particular change or development (Glenn, 2009).

Nature Futures Framework (NFF)—A heuristic that captures diverse, positive values for human–nature relationships in a triangular space (the NFF triangle; see Figure 5). We consider three main ways of valuing nature at each of the vertices (nature for nature, nature for society and nature as culture). The NFF builds on the three values of nature (intrinsic, instrumental and relational values, respectively) identified by the IPBES and repurposes it to make it actionable for the modelling and scenarios community. The NFF triangle illustrates how it is possible to emphasize a complex mixture of values for appreciating nature depending where in the triangle you are situated and thus allows for a plurality of perspectives to be held in different times, contexts and spaces. As such, the NFF approach and the triangle can be used both as a boundary object for continuously opening up more plural perspectives in the creation of nature scenarios (when referring just to the NFF triangle) and as an actionable framework for developing consistent scenarios and models across multiple scales and levels when referring to the overall process captured in Figure 1.

Pathways—Different strategies for moving from the current situation towards a desired future vision or set of specified targets. They are purposive courses of actions that build on each other, from short-term to long-term actions into broader transformation (Ferguson, Frantzeskaki, & Brown, 2013; Frantzeskaki, Loorbach, & Meadowcroft, 2012; Wise et al., 2014). The Three Horizons approach is often used to define such pathways in future visioning processes (Sharpe, Hodgson, Leicester, Lyon, & Fazey, 2016).

Scenarios—Plausible and often simplified descriptions of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces and relationships (Millennium Ecosystem Assessment, 2005). A scenario skeleton is a simplified outline of a scenario.

Seeds—Current positive and inspiring initiatives that hold potential to shape a more just, prosperous and sustainable future. They can be initiatives (social, technological, economic, or social–ecological ways of thinking or doing) that exist, at least in prototype form, and that represent a diversity of worldviews, values, and regions, but are not currently dominant or prominent in the world (Bennett et al., 2016).

Three Horizons approach—A simple, graphical and collaborative approach to build pathways for desirable futures based on a structured and guided dialogue considered along a temporal axis (now, near future, and far future): the first horizon is a business as usual scenario, the second horizon represents the necessary actions to move from the present to the desired future and the third horizon represents emerging paradigms, ideas and innovations for a desirable future (Sharpe, 2013; Sharpe et al., 2016; Figure 6).

Values—A principle or core belief underpinning rules and moral judgements. Values as principles vary from one culture to another and also between individuals and groups (IPBES/4/INF/13).

Visions—A desirable state in the future and therefore, a component of scenarios (the possible future states), demarcated from predictions (likely future states) and pathways (that lead up to the vision). Visions are usually seen as a desirable image of the future and can be defined as a compelling, inspiring statement of the preferred future that the authors and those who subscribe to the vision want to create (Wiek & Iwaniec, 2014).

Visioning—'The process of creating a vision, that is, a representation of a desirable future state, as opposed to scenario building (possible future states), forecasting (likely future states), and backcasting (pathways to desirable future states)' (Wiek & Iwaniec, 2014, p. 497).

chosen to organize the discussion process whereby participants are asked to individually reflect and generate ideas based on predetermined questions (Duncan, 2004). Subsequently, they collectively prioritize the ideas and suggestions issued by the group members (Clemen & Winkler, 1999; Harvey & Holmes, 2012). The process allowed us to combine individual and collective reflection, to explore novel concepts, and eventually generate a list of priorities (Coker et al., 2014; Rankin et al., 2016). There is some criticism of NGT in that it is a version of the Delphi method where the feedback step takes place during a face-to-face meeting of experts instead of filling in anonymized questionnaires. For such group settings, Ayyub (2001) highlights the following as potential limitations: socially reinforced conformity within the group, dominance of strong-minded or strident individuals, group motive of

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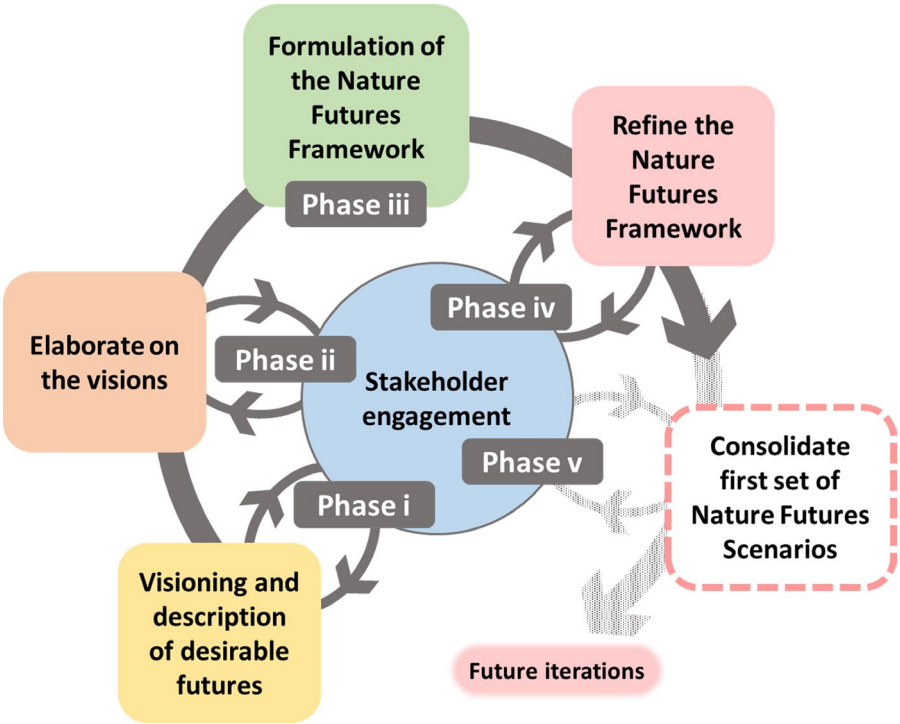

FIGURE 1 The five main methodological phases used for the development of Nature Future Scenarios, which are described in-depth in Section 3. This overall process illustrates how the Nature Futures Framework evolved. (Source: Authors' own)

quickly reaching agreement and group-reinforced bias due to common background of group members. To mitigate these potential limitations, the reflection process was guided by facilitators to ensure that individual personalities and other characteristics did not exert a disproportionate effect on outcomes. Multiple iterations of individual reflections followed by group discussion and synthesis is a valuable technique to avoid confrontation while allowing for a wider range of perspectives to be aired (Dalkey & Helmer, 1963). Multiple rounds of iterative feedback between multiple groups also allows for the attenuation of institutional and psychological biases (e.g. Hannagan & Larimer, 2010).

The description of the visions from Phase i were written in conjunction with all group members to ensure all aspects were covered and the mapping of the visions across a variety of characteristics was inductively undertaken as part of the workshop process. All the participants brainstormed and prioritized a set of characteristics that they thought were most relevant for describing the core aspects of the visions and these were then tested across all of the visions to see whether they were feasible. The final characteristics were chosen based on those that were most relevant to all the visions, and the visions were mapped according to group consensus, as a result of this inductive group process (see Table S1). More information on the specific analysis, including figures of the visions mapped across different characteristics, can be found in Lundquist et al. (2017).

During each stakeholder workshop (Phases ii and iv), notes were taken and these data were then recorded in a spreadsheet under thematic codes and analysed to see where there were overlaps and where gaps could be identified (see Table S3). Finally, expert opinion was used to analyse how the visions and stakeholder inputs could be optimally used to derive model-relevant scenarios that remained true to the co-produced, plural and multiscale nature of the undertaking. Through an inductive process that involved group analysis of the data in the visions and clustering into thematic components, the three dimensions of the triangle were derived (see PBL, 2018 for a full documentation of the expert workshop process undertaken in Phase iii). In Section 3 below, we present the results of how this iterative process was undertaken (Figure 1) as well as the outcomes at each of the phases that fed into subsequent phases.

2.3 | Ethical considerations

As this research was not undertaken through a university, there is no ethical clearance number. However, we endeavoured to follow all ethical guidelines in the involvement of human participants during the course of this research. The work presented was performed in accordance with the declaration of Helsinki and is in conformity with ethical standards of research. The authors have ensured that the information presented in this paper is either sourced from materials available in the public domain as a result of consent from participants or based on anonymous opt-ins to the research process by participants. Chatham House rules are applied in all workshops and nothing is attributed to any specific individual. All participants are authors of the publicly available workshop reports from which information was extracted for Phases i and iii (Lundquist et al., 2017; PBL, 2018). For the stakeholder engagement in Phases ii and iv, all participants were invited to opt in with an explicit explanation that their responses would be used as direct input to the future visions,

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but that all information would be anonymized. At the beginning of each stakeholder engagement process, we obtained verbal consent from all participants present that the outputs from the session may be used in research publications, but that no personal data would be used. The only personal details recorded were of the participants' nationality for regional representation purposes. More information on the source of data for each workshop is available in Supporting Information S2.

3 | METHODS AND RESULTS: DEVELOPING NATURE FUTURES

We use Figure 1 to structure this section and discuss the different methods and their results by each phase. A more in-depth description of the specific methods used in Phases i, ii, iii and iv is provided in Supporting Information S2.

3.1 | Phase i: Visioning and storyline development

The process began with a global participatory visioning workshop in Auckland, New Zealand, in September 2017 with 73 participants from 31 countries and representing all UN regions (Africa, Asia and the Pacific, Latin America and the Caribbean, Eastern Europe, Western Europe and others). The selection of stakeholders was a rigorous and iterative process that aimed to ensure as wide a range of geographies and perspectives as possible, drawing from a wide set of IPBES stakeholders (see Lundquist et al., 2017, Appendix A1 for the full selection criteria and description of the process). The final group included representatives from intergovernmental organizations, indigenous peoples from New Zealand, Europe, North America and Latin America, national government, non-governmental organizations, academia and the private sector and with a range of expertise on biodiversity topics, from urban development to agriculture to fisheries. The main objective of the workshop was the development of positive visions of nature and their associated storylines. It followed an approach designed to produce bottom-up, divergent visions of the future (Pereira, Hichert, Hamann, Preiser, & Biggs, 2018). The approach was selected with the intention of creating a space in which participants could think creatively to develop an inspired and powerful set of visions, grounded in existing 'Seeds' (see Box 1). The workshop process consisted of four steps (see Figure 2 and Lundquist et al., 2017, Appendix A2 for a detailed description of the workshop methodology). It is important to note that even though there was an explicit desire to include as many perspectives as possible, there is a clear bias in that only individuals who in some way prioritize and value nature are inclined to spend a full week formulating positive nature futures. The concerns of adequate representivity in a global undertaking such as this are paramount and will be picked up in the discussion.

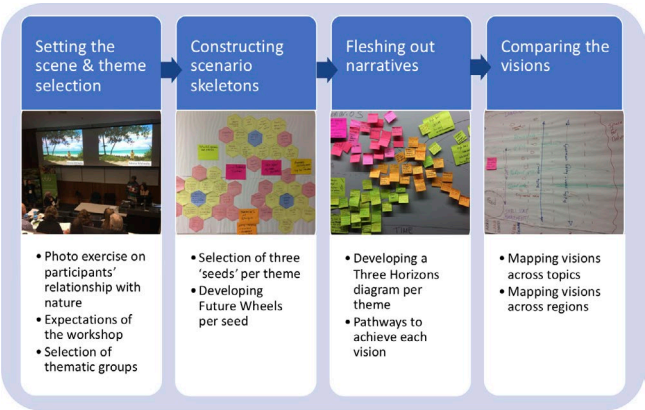

FIGURE 2 Four steps of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services Nature Futures Visioning workshop in Auckland (Source: Adapted from Lundquist et al., 2017)

The aim of the *first step* of the workshop was to set the scene and organize participants into thematic groups. In breakout groups, participants discussed themes that should be captured in future nature scenarios and then in plenary agreed on seven thematic, self-organized groups on freshwater, food, inclusive economics, urban–rural flows, indigenous and local knowledge, nature's dynamics and oceans. As these themes were brainstormed with the participants, they emphasize what those in the room thought were the most important thematic areas for discussion. Extending away from the thematic areas of focus into more holistic narratives for the development of scenarios was therefore acknowledged as a challenge that the team would face further into the process.

During the *second step* of the workshop, participants constructed scenario skeletons using three existing initiatives ('Seeds') that they believed would contribute to a better future that reversed the negative trends in their respective themes (Bennett et al., 2016, Box 1). In the *third step*, participants worked on fleshing out the narratives and exploring possible pathways to achieving the visions using the Three Horizons approach (Sharpe et al., 2016; Figure 6). This process was used to refine the visions, but did not develop specific timelines for change. As a result of these three steps, seven visions (i.e. potential Nature Futures) emerged (Table 1). These visions differ from scenarios in that they are representations of explicitly desirable futures, but do not describe pathways by which they each emerged from a baseline. As the method was designed to emphasize desirable futures, none of the descriptions are dystopian; rather different aspects of nature and its contributions to people emerge across the different visions.

Desired futures of peoples' relationship with nature varied substantially across these visions (Table 1). Some visions emphasize the indirect and intangible benefits of biodiversity, such as in *Urban Rural Flows*, *Nature's Dynamics* and *Culture*, while others emphasize the direct uses of nature, such as in *Food Production*. Acknowledging local ecosystem service flows and the development of multifunctional landscapes is an important component of *Urban Rural Flows*, *Water*, *Culture* and *Prosperity*. Others emphasize the management of global ecosystem service flows or the segregation of spatial uses of ecosystems, such as *Urban Rural Flows*, *Nature's Dynamics* and *Marine*.

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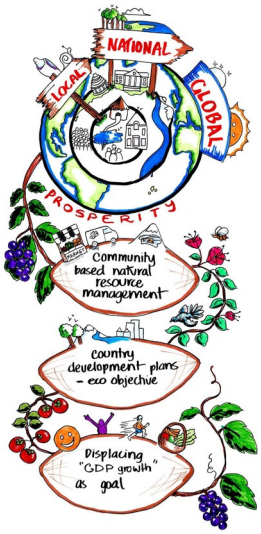
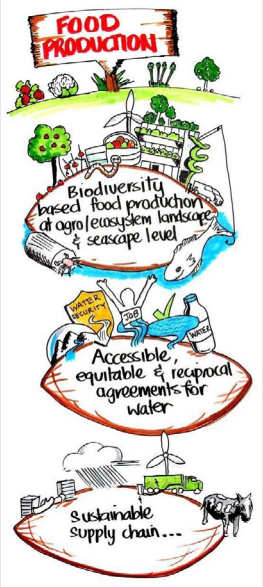
TABLE 1 Seven visions of positive Nature Futures that emerged from the Auckland workshop (adapted from Lundquist et al., 2017)

Name of vision (shortened title)	Description	Image of seeds (Source: Mary Brake, Reflection Graphics; Dave Leigh, Emphasise Ltd.; Pepper Lindgren-Streicher, Pepper Curry Design)
Nature-based inclusive prosperity (Prosperity)	This vision illustrates a world based on reconstructing global governance and institutional mechanisms in order to recharacterize economic drivers to include externalities and incentivize sustainable and natural resource use and sustain richly diverse cultures, societies and nature into the future	
Sustainable food systems (Food Production)	This vision illustrates a world where global food production systems are re-engineered, emphasizing sustainable supply chains and benefit sharing mechanism in place between producers, traders, transporters and retailers, grounded on biodiversity-rich food production that supports local and indigenous communities	
ReFooding and ReWilding the urban Rural flows (Urban Rural Flows)	This vision illustrates a world where urban and rural communities are reconnected with nature, achieved through ReGoverning to improve governance systems, ReFooding to reinstate localized ecosystem service flows and ReWilding solutions to free up space for nature across rural and urban areas	

(Continues)

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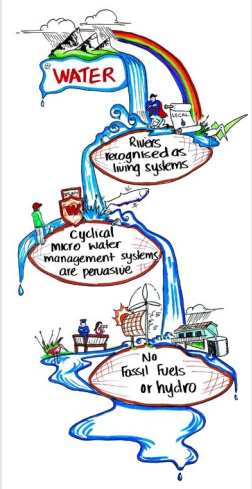
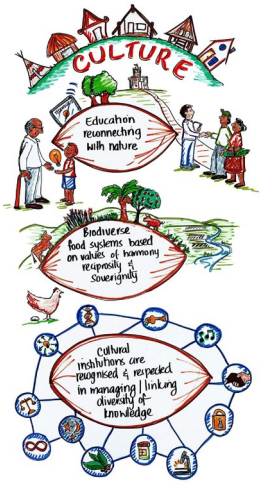
TABLE 1 (Continued)

Name of vision (shortened title)	Description	Image of seeds (Source: Mary Brake, Reflection Graphics; Dave Leigh, Emphasise Ltd.; Pepper Lindgren-Streicher, Pepper Curry Design)
Healthy Social–Ecological Freshwater Systems (Water)	This water-centric vision illustrates a world where innovative technologies and circular economies support efficient water use, extraction and recycling at localized scales,and legal rights and incentives are awarded to rivers as living systems	
A tasty World with values (Culture)	This vision illustrates a world where values of reciprocity, harmony and relationality drive humans' relationships with nature at all levels of human organization, where bio-culturally diverse and autonomous local food systems dominate, where there is respectful sharing among diverse knowledge systems and where governance systems recognize the rights of local producers and indigenous peoples with respect to territories, resources and knowledge	
Dancing with Nature (Nature's Dynamics)	This vision illustrates a world where nature is at the centre, and human societies both accommodate and benefit from natural environmental fluctuations. Dynamic societies and infrastructure emerge, with technological innovations that enable people and nature to adapt to the challenges of the Anthropocene	

(Continues)

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TABLE 1 (Continued)

Name of vision (shortened title)	Description	Image of seeds (Source: Mary Brake, Reflection Graphics; Dave Leigh, Emphasise Ltd.; Pepper Lindgren-Streicher, Pepper Curry Design)
Healthy oceans, happy communities (Marine)	This ocean-centric vision illustrates a world where the high seas are closed to resource extraction, and coastal ecosystems provide a wealth of ecosystem services, supported by long-term sustainability strategies by governments and businesses that empower local-based sustainable co-management practices. Novel technologies support behavioural change to lower impact diets and increase food production	

During the *fourth and final step*, participants re-organized themselves into different sub-groups to map the visions across topics that they decided were the most relevant for identifying similarities and differences between the visions. These topics included (Lundquist et al., 2017; Table S1):

- State of biodiversity
- Value of nature
- Management of nature
- Governance systems
- Production and consumption of ecosystem services
- Socio-economic development
- Use of technology
- Lifestyles

The sub-groups mapped the visions across the different topics, which helped to identify commonalities and differences between them (see examples of use in Figure 3; Table S1). The visions were then compared across regions (Africa, Asia, Europe and North America, Latin America, Oceania), so that the experts present from these regions could reflect on how existing positive actions for biodiversity, infrastructure or other social, political or economic actors specific to a region might facilitate or impede the implementation of particular visions (Table S2).

Shared themes across multiple visions include green infrastructure (see Tzoulas et al., 2007), a circular economy (see Korhonen, Honkasalo, & Seppälä, 2018), context-dependent learning to inform environmental governance (see Armitage et al., 2018) and the equalization and reduction of humanity's global footprint (see Hoekstra & Wiedmann, 2014)—overall a more 'responsible stewardship' relationship between people and nature. All of the visions require a societal paradigm shift and significant changes in values, echoing the call for transformative change necessary for the sustainable use of natural resources (IPBES, 2019). The seven Auckland visions became starting points to inform the rest of the scenario development process, but required a lot of refinement before they could be adapted, including moving away from some of the thematic foci to more holistic descriptions of nature.

3.2 | Phase ii: Elaboration of the visions through stakeholder engagement

As the Auckland visions were developed by a small group of stakeholders, a series of further stakeholder engagement processes were conducted. The main aim of these sessions was to test how well the visions resonated with a broader group of people, how best to communicate the visions in engagement processes and to get feedback as to what the gaps or potential inconsistencies were in the visions so that these could be accounted for in the development of the scenario narratives. These stakeholder engagements took place through ad hoc engagement in IPBES events, such as Plenaries and other meetings that brought together diverse groups of stakeholders, as described below. More information is available in Supporting Information A: Methods.

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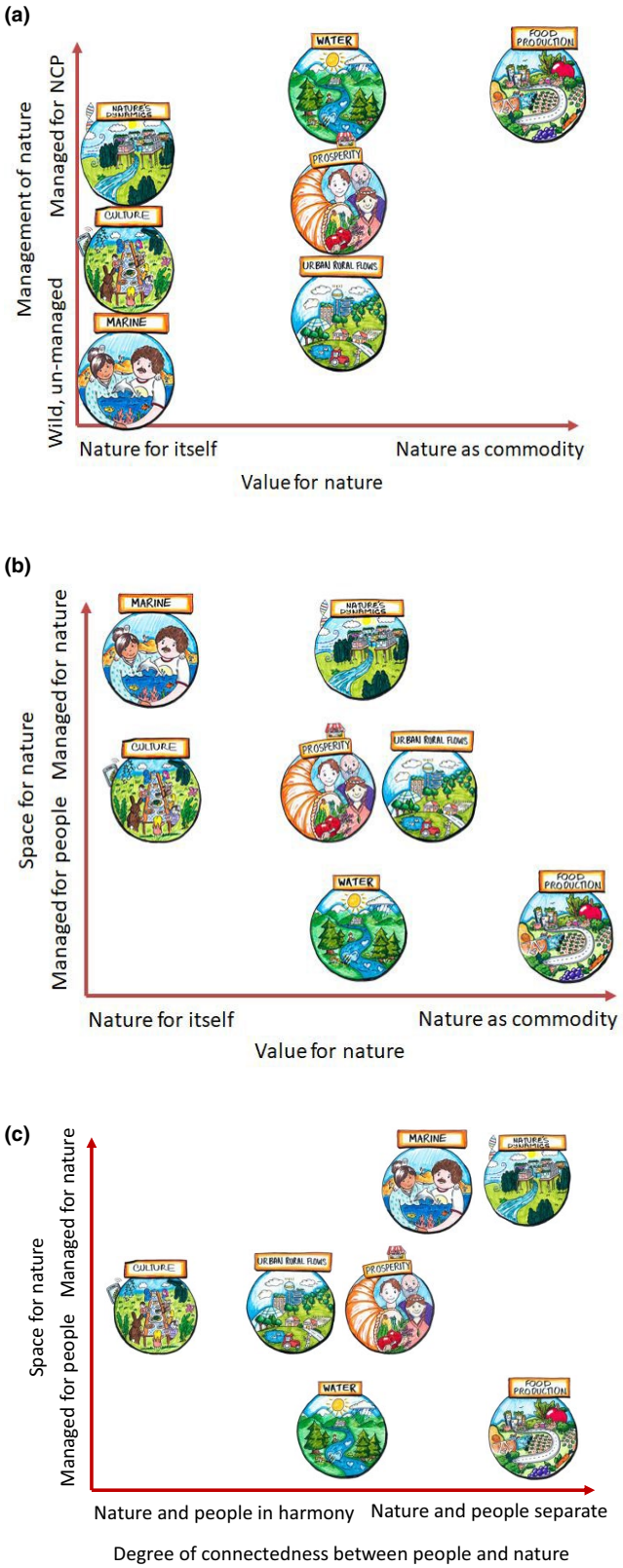

FIGURE 3 Mapping the visions across different dimensions. The axes capturing a range of values of nature from use to non-use including: (a) management of nature (*y*) and value for nature (*x*), (b) space for nature (*y*) and value for nature (*x*) and (c) space for nature (*y*) and degree of connectedness between people and nature (*x*). (Adapted from Lundquist et al., 2017)

3.2.1 | IPBES 6: Stakeholder day and plenary

In the margins of the sixth session of the IPBES Plenary (IPBES-6) and IPBES Stakeholder Day (Medellin, Colombia; 17–24 March 2018), a targeted survey was conducted to increase the 'reach' of our consultation activities. Two methods were used to generate further inputs, and materials were visualized and accessible both online and offline to facilitate accessibility and participation:

- An exhibition booth where visitors were able to add new ideas, identify gaps in visions and themes and modify or give feedback on the existing visions (Figure 4) by means of a paper survey.
- An online survey announced through both in person and social media channels.

All information from these stakeholder engagements were recorded to be used in the scenario narrative development process (Table S3).

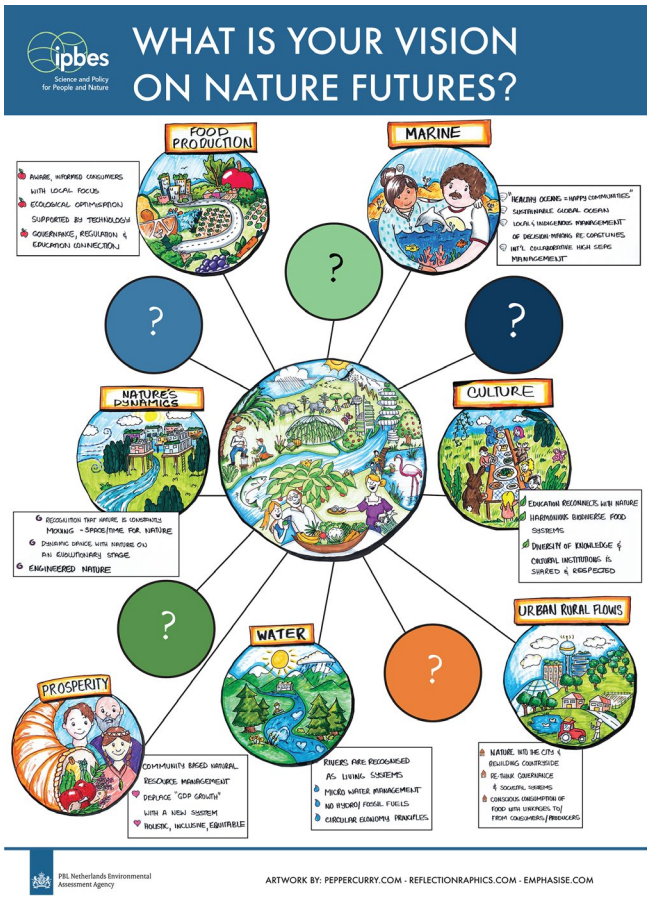

FIGURE 4 Poster used for IPBES 6 to illustrate and explain the current visions and to encourage people to suggest new areas or themes for exploration. (Source: Authors' own and images from Mary Brake, Reflection Graphics; Dave Leigh, Emphasise Ltd.; Pepper Lindgren-Streicher, Pepper Curry Design)

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3.2.2 | Natural Capital Symposium 2018

The seven visions were also presented at the Natural Capital Symposium, held during 19–22 March 2018 at Stanford University, where the results of the visions from the Auckland workshop were presented to attendees. This annual symposium attracts global participants from a variety of sectors and disciplines, including NGOs, business, government and academia. Key learnings included the need for approaches to align participants in a constructive process to explore and enrich visions even when time is limited, and to develop processes that work across different knowledge backgrounds, including those with limited familiarity with scenario approaches. Not all the visions resonated with stakeholders equally and it was not easy to explain the main differences between the seven visions because of the high degree of overlap in some instances. The need to differentiate between aspects of the visions was an underlying rationale in the development of the NFF in the next phase and was also a core aspect for consideration in the scenario development process.

3.3 | Phase iii: Formulating the Nature Futures Framework

In June 2018, an expert meeting was organized in The Hague (PBL, 2018). The objective was to develop a plan for formulating scenarios across scales based on the prior visioning process in Auckland, and to identify concrete tasks for engaging both the expert community and broader stakeholders in further co-development of the visions. In response to the feedback from the stakeholder engagement processes in Phase ii, the expert group decided that it was necessary to map out the seven visions that had been developed in Phase i to see what the fundamental overlaps, similarities and differences were. A group of scientists spent 3 days analysing the visions coming out of Phase i, and the elaborations that resulted from Phase ii, testing different parameters for mapping and categorizing them in a meaningful way (see PBL, 2018 for a full account of the workshop process). Considering that all visions were intentionally desirable visions of future human–nature relationships, and that some were narrower in geographical or ecosystem scope (e.g. covering freshwater or marine systems), it was clear that the parameters for separating them would need to be clear and consistent. After many discussions the experts came to realize that underpinning the visions were three value perspectives for how people relate to nature (Figure 5).

Building on the IPBES guidance on multiple values that identify intrinsic, instrumental and relational values for nature (IPBES, 2015), but seeking to find short and descriptive names for these perspectives they were called:

- *Nature for Nature*, in which nature has value in and of itself, and the preservation of nature's diversity and functions is of primary importance;
- *Nature for Society*, in which nature is primarily valued for the benefits or uses people derive from it, and which could lead to an optimization of multiple uses of nature and
- *Nature as Culture*, in which humans are perceived as an integral part of nature, and therefore what is valued is the reciprocal character of the people–nature relationship.

The NFF builds on the three values of Nature (relational, instrumental and intrinsic values) identified by the IPBES and repurposes it to make it actionable for the modelling and scenarios community.[1] According to the IPBES guidance on multiple values of nature, intrinsic values refer to non-anthropocentric values associated with nature and its contributions to people and are independent of any human experience and evaluation (IPBES, 2015). Referencing Pascual et al. (2017), they refer to the inherent value of nature and its components, which is not generated by human beings. Instrumental

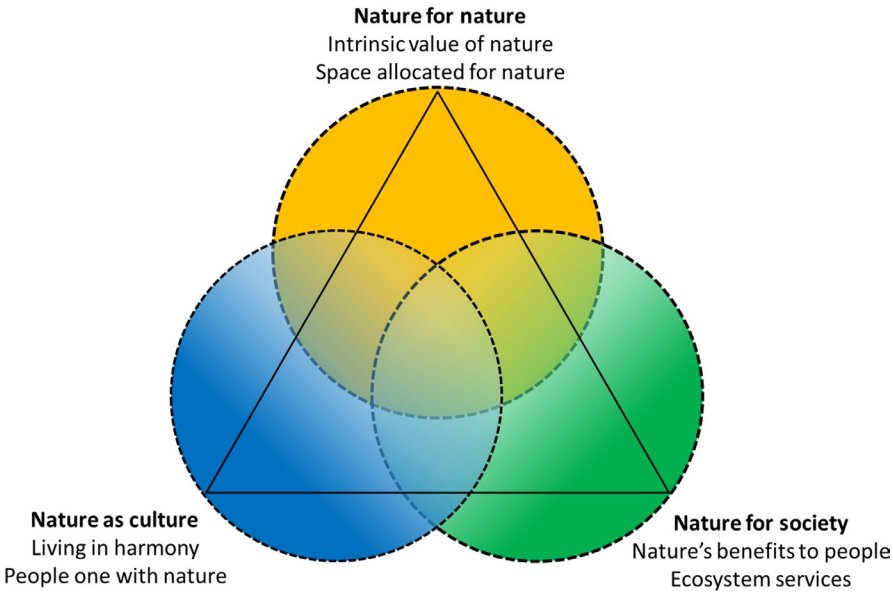

FIGURE 5 The Nature Futures Framework triangle with a list of some possible synonyms for the value perspectives that are used by various actors. (Source: PBL, 2018)

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values often relate to NCP and refer to the value attributed to something as a means to achieve a particular end. Finally, relational values reflect relationships 'with natural entities to the extent that such relationships are embedded in people's identity and every day' (IPBES, 2015).

The expert group recognized the importance of elaborating on what futures in the corners and along the sides of the triangle look like (scenarios), and of identifying the transformative changes required to achieve them (pathways). The corners would therefore serve as reference points for analysing differences and convergences in actions motivated by the value positions. When combined, these plural value perspectives are more likely to be situated closer to the middle of the triangle in a way that appreciates all perspectives, and is not just dominated by one perspective. However, in reality, in order to strike that balance whilst maintaining diversity, it was recognized that some areas of the triangle will be emphasized more by some people in certain times and places compared to others. Understanding how people understood and appreciated this nuance and flexibility of the NFF was essential to the process and so further stakeholder engagement was undertaken. Important to note is also that all three value perspectives illustrate positive visions of the future human–nature relationship. The common situation of undervaluing nature that is prevalent in many societies today is not visible in the NFF.

3.4 | Phase iv: Further refinement of the NFF through stakeholder engagement

Before moving on to develop scenario narratives for modelling using the NFF triangle, it was necessary to test how stakeholders received the framework as a clear and understandable heuristic, and whether it was a useful way to frame the complex discussion about plural nature-society value relations and whether we could start to populate scenarios of what a world would look like that emphasized aspects of the triangle's value perspectives. We thus developed a set of participatory processes for testing the NFF with a diverse group of the biodiversity community. The description of the Triangle exercise that took place in October 2018 in Bonn, Germany with a group of 42 attendees, in the margins of IPBES meetings is explained in Supporting Information S2. The aim of that exercise was to develop a method for allowing people to engage with the NFF and to see whether it was understandable to a diverse group of people. Below we describe a process undertaken during the 14th Conference of the Parties (COP) of the Convention on Biological Diversity (CBD) in 2018.

3.4.1 | CBD COP 14: Three horizons approach

Further stakeholder engagement was held during an interactive workshop in the Rio Conventions Pavilion at the CBD COP in Sharm El-Sheik, Egypt on 20 November 2018. Results are extracted from materials made available in the public domain by the International Institute of Sustainable Development (IISD) based on verbal consent provided by participants on-site during the event (IISD, 2018). The group exercises followed the three horizons approach (Figure 6), where participants were invited to discuss future visions and pathways to achieve them (Curry & Hodgson, 2008; Sharpe, 2013; Sharpe et al., 2016). Participants began by creatively envisioning a more desirable future for their thematic areas (Horizon 3) and then working back to the present system (Horizon 1). Discussing Horizon 2 was the final step, representing the transition zone between the present and the future where different pathways can be articulated. The questions asked in the process were:

- **Horizon 3**: *What is the desirable state for this value perspective in the marine/rural/urban ecosystem?*

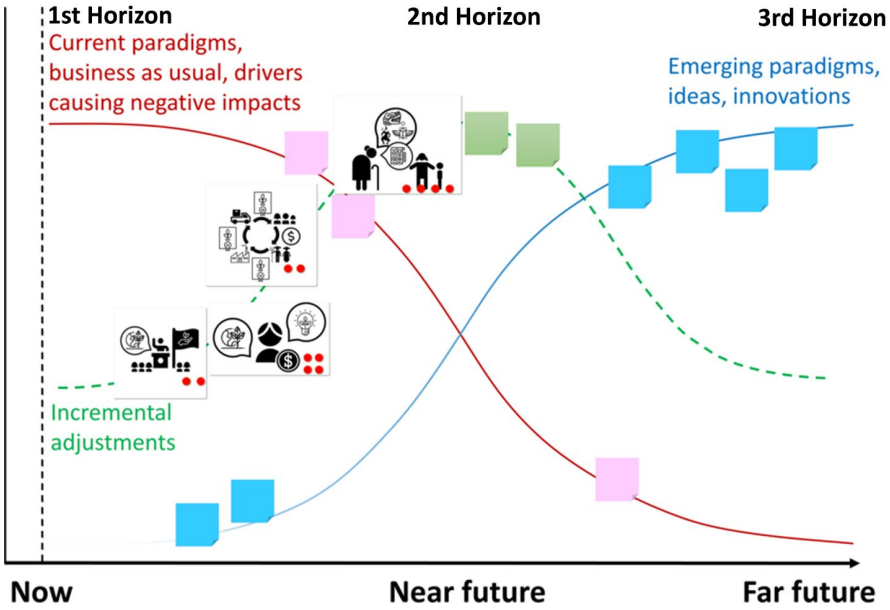

FIGURE 6 Three Horizons heuristic tool used as a method in the CBD COP 14 workshop. The red line of Horizon 1 represents the current paradigms, business as usual and drivers causing negative impacts. The blue line of Horizon 3 represents emerging paradigms, ideas and innovations for a desirable future. The green line of Horizon 2 represents the necessary actions and adjustments that are required to move from the present to the desired future. (Source: Authors' own)

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- **Horizon 1**: *What are the most important direct and indirect drivers of change in nature, and what barriers prevent us from reaching that desirable state in the marine/urban/rural ecosystem?*
- **Horizon 2**: *What actions or policy interventions could address the obstacles and allow transitions towards the positive Nature Futures of the third horizon?* (bearing in mind the drivers and barriers identified in Horizon 1)

The discussions were facilitated using a poster-sized template of the three horizons and participants were invited to note down their ideas on post-its or to use the predesigned icons and add them to the template to record their discussions (Figure 6).

This interactive exercise brought together 39 participants from 22 nations. These participants produced three sets of posters focusing on each of the three perspectives of the NFF in a marine, rural and urban environment. Based on the group discussions on the three horizons approach, Table 2 summarizes the group discussions of what a positive future for the three sectors could look like if diverse values for nature were explicitly recognized. The information from these processes were recorded (Table S3) to be used in the elaboration of the scenarios in Phase iv.

Overall, these exercises demonstrated that even when starting from different values perspectives, convergence and synergies can occur when considering the pathways towards the desired futures with the NFF. Synergies across different groups included sustainable consumption, deepening the role of technology within nature while also encouraging living in harmony with nature, and emphasizing the co-evolution of humans with nature. Participants stated that using the NFF as a starting point to make different value perspectives explicit was helpful for policymakers as it allowed them to consider different options and alternative sustainability trajectories.

3.5 | Phase v: Towards a first set of Nature Futures Scenarios

The 7th session of the IPBES Plenary (IPBES-7, April–May 2019 in Paris, France) decided to establish a task force on scenarios and models to advance work on scenarios and models of biodiversity and ecosystem functions and services, as part of the new IPBES work programme up to 2030, which IPBES-7 approved. The mandate of the task force is to advise IPBES experts working on assessments on the use of scenarios, and to catalyse the further development by a variety of stakeholders including the modelling community, of scenarios and models for future IPBES assessments. The task force is following up on the work performed by the expert group on scenarios and models during the first work programme of IPBES (2014–2018). In order to fulfil this objective, the task force is currently developing a package of NFF-related material. A process is now underway to develop six illustrative scenarios of futures based on an extreme interpretation of the three value perspectives and the edges where they intersect. A core aspect of this process is to ensure that there is maximum diversity between the different scenarios so that we are able to capture a wide spectrum of possible futures based on plural value perspectives. Engaging the broader scientific community in these endeavours is of great importance and this will be discussed below in Section 4.3.

3.6 | Limitations and lessons

The Nature Futures process required dealing with changes, including a change in membership of the expert group when it became an IPBES task force on scenarios and models in November 2019. Although there are multiple benefits from being able to associate with an intergovernmental platform such as IPBES, the fact that the project is not set up as a

TABLE 2 Key highlights from the discussions in the six groups (see Table S3 for a full description)

Value perspective	Marine	Rural	Urban
Nature for Society	Stronger enforcement of laws and regulations as an important step towards achieving the desired vision of plastic-free, healthy oceans, serving as a source of jobs and clean energy	The potential contribution of blockchain technology and the adaptation of agricultural practices to overcoming some of the negative drivers such as bad practices in agricultural production	The need for a circular economy, increased blue/green infrastructure, ecotourism and incentives for urban farming, which would require alignment of priorities across different institutions charged with urban planning
Nature for Nature	Ideal future is one of healthy oceans, healthy coastlines and healthy ecosystems, but corruption and overfishing are major impediments to this realization	There is a possibility of envisioning a future that excludes humans from rural areas (Half Earth), but the preferred focus is how to achieve a well-functioning ecosystem with clean air and water. A decrease in monocultures and pollution are ways to contribute to this goal	Sustainable cities with organic local food production and increased overall connectivity with nature as the desirable future, which would require new laws tax reforms, and better spatial planning to ensure connectivity between rural and urban areas
Nature as Culture	People's perception of oceans as being the root of sustainability problems, and the need to shift away from seeing oceans as a property that can be exploited as amusement parks, and instead revive the spiritual connections with them	The need for a change in lifestyle and education, and better management, with more food diversity, eco-friendly farming and increased engagement of youth. The role of technology in overcoming these challenges, and closing the gap between urban and rural areas is key	More equity in access to biodiverse urban spaces, green buildings and community gardens. There is a need for new social norms, mindsets and standard-setting initiatives that connect cities to nature

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regular research project brings constraints. These constraints include the specific protocols for convening groups: whilst it is extremely helpful to be able to draw on the large IPBES stakeholder community, sometimes the rules can be difficult to implement and it can become expensive to generate co-funding for non-supported members to attend meetings. As this process sits outside of a dedicated research project, the ability to mobilize funding to host stakeholder engagements has been a big limiting factor. The mandate of the task force being to 'catalyse' work means we depend on interactions with other researchers and stakeholders, and the fact that the expert group is voluntary and cannot dedicate excessive amounts of time and resources to the process are further constraints.

Within this context, a chief lesson is that creating a new generation of scenarios and models requires a commitment to participatory processes that makes those involved feel comfortable to express their viewpoint openly (Hebinck, Vervoort, Hebinck, Rutting, & Galli, 2018). The management of group dynamics, especially across disciplines, cultures and languages must therefore acknowledge power differentials and the pluralities associated with cultural contexts (Marshall, Dolley, & Priya, 2018). A core aspect of the approach was to ensure co-production of knowledge through approaches such as employing a cultural guide to help with workshop planning, taking time to establish ground rules with local facilitators, a strong focus on creating a sense of community and mutual respect among the participants in the process, employing techniques such as Chatham House Rules, and negotiating the confidentiality of data. These methods support trust building and represent an investment in social capital, which is needed to progress any collective effort.

4 | DISCUSSION

The ultimate aim of the Nature Futures endeavour is to develop a process for creating multiscale scenarios of desirable futures for nature, which have been legitimized through a co-production process that includes a plurality of perspectives. The IPBES expert group embarked on an iterative process that resulted in the development of the NFF as a tool for engaging a pluralistic set of positive perspectives on human–nature relationships and as a framework for constructing multiscale scenarios. The NFF serves as a boundary object that provides a platform for practitioners, natural and social scientists, policymakers and modellers to reflect on and compare which types of values and which types of relationships with nature are being analysed, discussed and compared. We believe that the use of the NFF within the overall framework enables more nuanced and relevant dialogue around what possible futures for nature can be created. It also forms a foundational framework from which further scenario work can be undertaken. This is discussed more in Section 4.3.

As such, we argue that the contribution of the NFF is twofold:

1. Its ability to hold a **plurality** of perspectives on what is **desirable**, which enables the development of joint goals and visions and recognizes the possible convergence and synergies of measures to achieve these.
2. Its **multiscale** functionality for elaborating scenarios and models that can inform decision-making at relevant levels, making it applicable across specific places and knowledge systems.

4.1 | Holding a plurality of values and perspectives on desirable futures

4.1.1 | Desirable futures

The world needs desirable visions, including targets to stimulate action towards achieving them, as illustrated by the normative power of the SDGs and the well-below 2°C target of the Paris Agreement (UNEP, 2019). However, discussions on such desirable futures around biodiversity and particularly the post-2020 agenda in the CBD have tended to accentuate the perceived conflict between diverse perspectives of what a desirable future for nature looks like, problematizing the diversity of underlying values of the human–nature relationship. Many players in the science–policy arena actively lobby for implementation of alternative ideas, but often these ideas do not align, especially when they are popularized and differences are emphasized, which can result in tensions that potentially undermine a collective effort. A clear example is the land-sparing (high-yielding agriculture with a small land footprint) versus land-sharing (low-yielding, wildlife-friendly agriculture on larger tracts of land) debate that offers two alternative pathways for agricultural and urban development to enable better outcomes for local and global biodiversity (Kremen, 2015; Loconto, Desquilbet, Moreau, Couvet, & Dorin, 2018). The concept of 'Half-Earth' introduced by the naturalist E.O. Wilson has gained significant traction (Büscher et al., 2017; Kopnina, Washington, Gray, & Taylor, 2018; Wilson, 2016), while other groups advocate for 30% of the ocean to be protected (Dinerstein et al., 2019). An altogether different solution is found in green growth for sustainable development, celebrating natural capital accounting, nature-based solutions and payment for ecosystem services schemes (Bull & Strange, 2018; Mandle, Ouyang, Salzman, & Daily, 2019; Russi & ten Brink, 2013; TEEB, 2010, 2018). Other research articulates the need for a look at alternative economic models for a flourishing nature (D'Alessandro, Cieplinski, Distefano, & Dittmer, 2020; Otero et al., 2020).

There is a diversity of perspectives in the global conservation community on how to conserve nature (Mace, 2014; Sandbrook, Fisher, Holmes, Luque-Lora, & Keane, 2019). Mace (2014) proposed four stages in the evolution of the nature conservation paradigm, from 'nature for itself' to 'nature despite people' to the 'nature for people' approach embodied in the Millennium Ecosystem Assessment (2005). A fourth stage posits that a more nuanced 'nature and people' approach has recently been taken up that recognizes the dynamic relationship between people and nature. These different framings have implications for environmental management and have led to some tensions in the conservation community

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(Sandbrook et al., 2019). Sandbrook et al. (2019) argue that future debates and policy processes should emphasize working through the more contentious issues, and ensure inclusion of the perspectives of under-represented groups in conservation who may not share the views of those in more powerful positions. To this end, the NFF as a heuristic device that has been developed in an interdisciplinary process with widespread stakeholder engagement, can potentially facilitate constructive dialogue to identify and focus on shared ambitions for collective action. By focusing on the positive relationships (i.e. not emphasizing the 'nature despite people' perspective, but including it in the nature for itself value), the NFF work can help to identify and bridge dominant perspectives in the world of nature conservation.

4.1.2 | Value pluralism

The embracing of value pluralism makes it possible to fit the NFF to different contexts and identify different behavioural changes associated with particular political, legal and socio-cultural perspectives. By enabling the identification of more diverse types of policy responses and actions that can restore the living world and focusing on the variation among people's relationships to nature, the NFF highlights that acknowledging people's diverse relationships with nature is essential for discussing nature futures and coming to an agreement on ways to achieve a more desirable future. Often, assessments of nature focus on natural sciences or economics and do not consider why and how people care about nature (IPBES, 2019; Millennium Ecosystem Assessment, 2005; UNEP, 2019). In contrast, the NFF approach focuses on reciprocal relationships between people and nature (within the whole of the triangle space) rather than only people's impact on nature, or nature's impact on people. It emphasizes the importance of a pluralistic notion of values compared with monistic approaches to human–nature relationships dominated by a single worldview (that might overemphasize only one target, such as the conservation of biodiversity, economic growth, social development or poverty alleviation, the inclusion of indigenous knowledge) as discussed in the IPBES conceptual framework (Díaz et al., 2015; IPBES Plenary, 2016; Pascual et al., 2017).

The IPBES values framework, referring to intrinsic, instrumental and relational values for nature that are captured in the NFF, and builds on an ongoing scholarship that engages with the need for a diversified framing on values of nature (Chan et al., 2016; Chan, Gould, & Pascual, 2018; Chan, Satterfield, & Goldstein, 2012; O'Connor & Kenter, 2019; Piccolo, 2017). Chan et al. (2016) build on the IPBES guidance and emphasize the importance of the relational values approach, arguing that recognizing these values is critical to the genuine inclusion of diverse groups in environmental stewardship. Piccolo (2017) has added to this debate by arguing that depicting intrinsic values as part of a dichotomy between anthropocentric and ecocentric values is unhelpful and that any attempt to reframe the discussion about values and environmental protection through more formal recognition of relational values will need to more clearly address how relational and intrinsic values coexist. Together with colleagues, he goes on to call for ecocentric values to be a core aspect of the transformation of human's relationship with nature and argues that conservation used to be at the forefront of this approach (Piccolo, Washington, Kopnina, & Taylor, 2018). Extending the discussion of intrinsic values of nature, O'Connor and Kenter (2019) use the life framework for values to make the case for integrating the more-than-human components of intrinsic values that goes beyond classifications of ecosystem services and NCP.

While the NFF builds on the relational, instrumental and intrinsic values, the three perspectives do not map unequivocally to these values and allow for their coexistence, addressing some of the criticisms of Piccolo (2017). Nature for nature represents both intrinsic values and instrumental values such as existence values and non-material benefits from nature. Nature for society is dominated by the use and indirect use of a subset of instrumental values, while nature as culture captures the relational values, but also the non-material benefits associated with cultural construction and interpretation of nature. The NFF approach is being developed to support scenarios and therefore is closer to stakeholder perspectives than conceptual classifications of the types of nature values. In addition, it recognizes that most stakeholders will find themselves in intermediate positions of the preference space, where all values and perspectives coexist.

4.1.3 | NFF as a boundary object

Reinforcing the call by Tadaki, Sinner, and Chan (2017) to move away from theoretical gridlock within the environmental values debate and into a space where the valuation of diverse values of nature can be means of citizen empowerment, the methodological approach of the NFF is an attempt to create a boundary object for bringing different disciplinary perspectives and worldviews together. The creation of a boundary object in the scientific process can be a useful strategy for reconciling tensions between different viewpoints and translating between them so that progress can be made (Star & Griesemer, 1989). As such, boundary objects must be both adaptable to different viewpoints whilst also being robust enough to maintain identity across them (Star & Griesemer, 1989). In the biodiversity conservation context, boundary objects have proved to be important tools for navigating different scalar perspectives for improved decision-making (Gray, Gruby, & Campbell, 2014). The IPBES Conceptual framework itself has been described as a boundary object for opening up the science–policy interface for broader engagement with plural ontologies and epistemologies (Borie & Hulme, 2015; Scarano et al., 2019). Based on the stakeholder engagements described in Section 3.3, we argue that the NFF triangle has turned out to be useful as a boundary object for bridging multiple disciplines and stakeholder perspectives. As the final outputs of the Nature Futures process must be relevant for a wide audience, including the modelling community, having a common conceptual lynchpin in the NFF has been critical for creating buy-in and understanding across different groups.

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The aim of the NFF is not to replace the frameworks described above, but to provide a heuristic that can hold these different conceptualizations in order to provide a simple, but effective, tool for the creation of multiscale, plural biodiversity scenarios. As such, it is intended to be used as a heuristic device for holding ongoing engagements between diverse perspectives. As intergovernmental assessment processes have a strong influence on how the spatial dimensions of environmental problems are designated and thus how power relations are accordingly reconfigured across different scales and levels (Beck, Esguerra, & Goerg, 2017), a tool through which to unpack these relations and empower different spatial scales can be an important offering. By capturing diversity in an accessible heuristic, the NFF has the potential to support IPBES assessment work by operationalizing the platform's principles: promoting a collaborative approach; facilitating an interdisciplinary and multidisciplinary approach; engaging with different knowledge systems, including indigenous and local knowledge; and ensuring full, effective balanced participation across national, sub-regional and regional levels. The NFF approach also complements ongoing IPBES work, especially that of the Values Assessment which will be considered by the 9th session of the IPBES Plenary in 2022. Future assessments, including those on transformative change, the nexus of biodiversity, water, food and health and business and biodiversity, will be able to utilize the NFF as an overarching framework around which to organize the analysis of scenarios and models that deal with these topics.

4.2 | Multiscale functionality to inform decision-making at relevant levels

Although a growing body of literature has identified the challenges and possibilities associated with developing cross-scale scenarios (Biggs et al., 2007; Kok, Biggs, & Zurek, 2007; Mason-D'Croz et al., 2016; Mistry et al., 2014; Palazzo et al., 2017; Zurek & Henrichs, 2007), it has mostly focused on rescaling global scenarios for regional and local use using various algorithms (Häyhä, Lucas, van Vuuren, Cornell, & Hoff, 2016; Kok, Pedde, Gramberger, Harrison, & Holman, 2019; Kok et al., 2016; Mason-D'Croz et al., 2016; Palazzo et al., 2017). Effective multiscale, and particularly cross-scale analysis is difficult, and it is not only a challenge of scenario planning. Disciplinary research often re-emphasizes the problems of scale: ecologists and social scientists traditionally frame their research questions at different scales and consider different facets of natural resource management, setting different objectives and using different language (Montana & Borie, 2016; Stevens, Fraser, Mitchley, & Thomas, 2007), which makes it difficult to connect scales. Within disciplines, scale remains a problem, due to the scale bound nature of research problems and data collection (Levin, 1992).

The NFF has been explicitly designed by an interdisciplinary group of researchers to be used across multiple scales, potentially, but not necessarily, combining scales in the same framework within a cross-scale approach. Overcoming philosophical and disciplinary challenges and embracing the plurality of knowledge systems that lies at the heart of IPBES, were central goals of the expert group as they developed the NFF. Bridging interdisciplinary barriers is required to be able to incorporate more diverse knowledge systems into environmental assessments (Obermeister, 2017). Although not perfect, the group made a lot of effort to embrace a diversity of knowledges, methods, research and discussion styles and this resulted in the NFF triangle operating as a boundary object that can work not only across disciplines, but also across scales.

It is important to point out that packaging and providing knowledge for policy is not a neutral activity, especially when navigating across scales of relevance that requires translating the global environmental knowledge of assessments into a form that is usable by decision-makers that operate at a different level, usually that of a nation state (Turnhout, Dewulf, & Hulme, 2016). The NFF is not a neutral object that was developed with buy-in from the whole world, and this must be fully acknowledged. A key rationale for the development of this paper is for the NFF development process, with all its associated challenges, to be transparently laid out for all to be able to engage with the process, critique it and improve on it in future iterations. Such epistemological agility is necessary when co-producing knowledge with diverse peoples across different scales (Haider et al., 2017), as highlighted by the work on the multiple evidence base that conceptually informs the NFF as a tool to feed into intergovernmental processes like IPBES and the CBD (Tengö et al., 2017). Finally, the flexibility of the NFF to work across multiple different contexts and with a variety of stakeholders requires it to be relatively simple and this means that it can lose a lot of the nuance and subtlety that is sometimes of great importance when engaging diverse perspectives. This is a core constraint of the NFF, however, its work as a boundary object can alleviate some of this simplification.

4.3 | Next steps in the Nature futures scenarios process

In order to broaden the engagement with the NFF and to get wide buy-in to its adoption as an actionable framework by diverse researchers, it is imperative that future steps in the process seek actively to involve more people and expertise. The next steps in the scenario development process are to extend the use of the NFF in multilevel case studies to test its relevance across diverse ecosystems, bio-cultural regions and geographical scales. This will involve both the development of new scenarios based on the framework (discussed in Section 4.3.1) as well as the analysis of existing scenarios within the NFF framework. The articulation of variables and indicators that can be quantified by the biodiversity modelling community is also needed. It is hoped that the insights from the case studies will be input for further refinement of the global scenarios, as well as for developing more diverse sets of indicators to assess the progress towards the goals for nature that incorporate more diverse value perspectives (IPBES/7/INF/11[2]).

To be most effective, the development of the multiscale scenarios needs to be coordinated across work that is underway

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elsewhere. Linking to ongoing work on global scenarios connected to the IPCC and UNEP's Global Environment Outlook and Global Biodiversity Outlook, as well as to business and government scenarios, and to the increasing number of local, national and regional social–ecological scenarios, is crucial to gain traction in the user community. This requires strategic planning and innovative communication platforms that engage busy people across a range of interests and scales. Such work can help to catalyse greater societal support for enhanced conservation of nature, but it requires an ongoing commitment of resources, particularly in terms of time and funding. As such, we set out the following two key processes in which we invite interested research and practitioner communities to help take part in furthering.

4.3.1 | Multi-level case studies

To better represent the global diversity of values, ecosystems and local contexts, a broader engagement is needed with a wider range of stakeholders situated in different contexts, and including groups such as indigenous peoples, the youth and the private sector. These engagements could be undertaken with support from several IPBES task forces, including the capacity-building task force that has already organized a youth engagement around the NFF and futuring processes (IPBES Capacity Building, 2019) as well as the indigenous and local knowledge task force that convenes dialogues with indigenous peoples and local communities for ongoing IPBES assessments. Mobilizing the research community to use the NFF in their own work is critically important to provide a richness of different case examples. Innovations in research methods can also allow a large group of people from around the world to engage with the scenario process by using online methods that allow many people to contribute their perspectives and narratives. For example, SenseMaker® uses an online application to capture a variety of perspectives and narratives (Van der Merwe et al., 2019). These are just some of the options that we encourage the research community to undertake with us in moving forward the nature futures agenda.

The aim of having a set of case studies is to populate the triangle with examples of how nature values are represented in different locations, across different spatial scales and how these could change into the future (Figure 7). For example, people's relations to nature will vary between the residents of the city of Singapore, Siberian reindeer herders and communities in the south of France. For clarity, it is important to demonstrate that there are two different ways of using the NFF triangle to visualize nature futures in case studies. The first is by identifying a position within the NFF triangle space that represents the relative emphasis of the three value perspectives. The second is represented in Figure 7, where the desired state of the system is represented by a space connecting three points along each of the triangle's vertices, indicating how well that particular value perspective is achieved. This approach is more appropriate for a bottom-up approach to global scenario narratives as it is easier to amalgamate the desired state space rather than a point within the triangle.

The goal of such efforts is to identify key variables and indicators for different nature perspectives that can help the community operationalize this framework in a way that is both globally comparable and locally relevant, as well as identify commonalities and differences among desired visions of nature around the world. Comparison of such case studies can also be used to identify shared drivers, and ignored or hidden teleconnections between local places (Martín-López et al., 2019). This type of comparison is necessary to

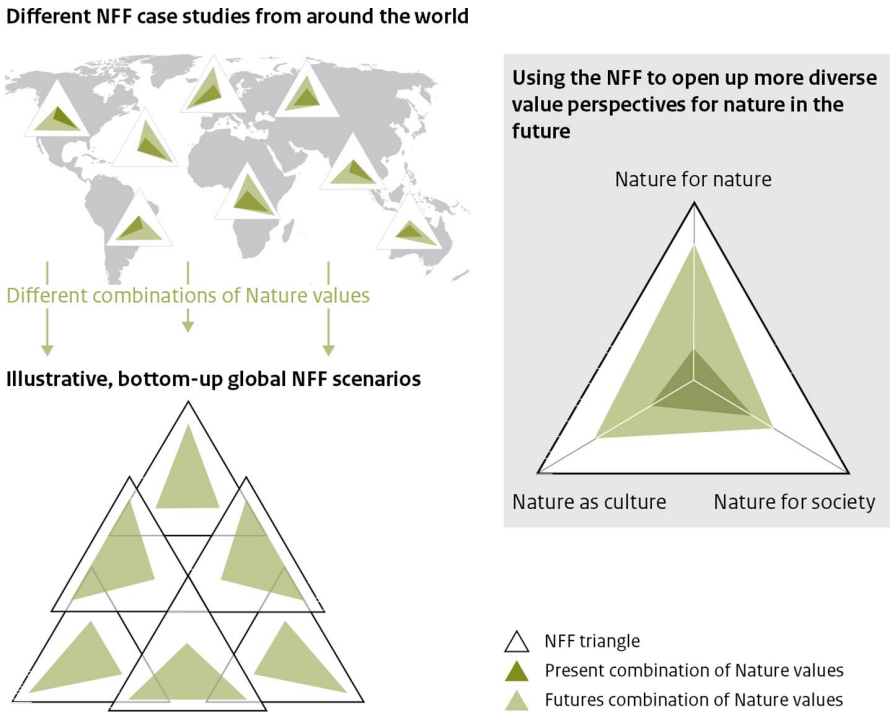

FIGURE 7 Local NFF case studies that engage a variety of actors in different social, geographic and ecological contexts are vital for understanding how global change varies from place to place, the diversity of nature values and how local places connect to global processes. When scaled to the global level, the richness of this bottom-up information can be combined to showcase a diversity of options of what desirable futures for nature could look like globally, based on different emphasis on the nature value perspectives. The use of the NFF enables an opening up of the value perspective space when describing possible nature futures as compared to the present state. (Source: Authors' own)

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ensure that global analyses adequately identify the cross-scale dynamics that are shaping the world.

Having the NFF as a clear common framework linking these case studies will be important for consistency, especially for providing inputs for the modelling community. We therefore encourage those who are interested in applying the NFF in their context to undertake scenario processes using the NFF as a foundation to ensure consistency and comparability of the findings. Existing examples include a youth workshop organized in Brazil by the IPBES task force on capacity building as well as a case study in the National Park Hollandse Duinen in The Netherlands. More substantial guidelines on how to get involved are also being developed.

As with all participatory visioning and scenarios processes, issues of power, politics and representation, come to the fore (Hebinck et al., 2018; Oteros-Rozas et al., 2015; Pereira et al., 2018). Recognizing inherent biases whilst trying to foster a wide range of perspectives is also a methodological challenge (Schirrmeister, Göhring, & Warnke, 2020). Navigating these dynamics in a global, participatory process is particularly challenging as it will never be fully representative of the whole world. Furthermore, in asking for the research and practitioner communities to undertake case studies, there is no systematic plan for ensuring representativeness. However, we hope that by encouraging the involvement of the wider community, by leveraging the diversity of stakeholders in the IPBES process and by actively targeting our own research to ensure the views of under-represented groups such as indigenous knowledge holders, are included, that this process will be a significant step towards a new set of globally relevant, but locally applicable desirable nature scenarios.

4.3.2 | The application of the NFF for the modelling community

Given the complexity of dynamic social–ecological systems, which encompass interconnected natural and human systems that are multi-dimensional with countless feedbacks within and between systems, integrative modelling of environmental scenarios has been a challenge (Pereira et al., 2010; Rosa et al., 2017). In Nature Futures modelling, connecting the visions to the ongoing and emerging work of modelling groups will require substantial investment in modelling capacity and capability associated with participatory modelling, social–ecological feedback modelling, cross scale modelling and understanding leverage points for transformative change (Leclere et al., 2018). The application of the NFF requires a modelling capability for assessing interlinked impacts of dynamic nature on societies as well as transformative change processes, with better integration of the feedbacks within linked human–environment systems.

A considerable number of indicators have been selected for use in IPBES regional and global assessments as documented by the IPBES task force on knowledge and data.[3] However, there are substantial gaps in modelling elements and indicators for socio-economic elements and human well-being, and few available indicators that are relevant to the Nature as Culture value perspective (Mastrángelo et al., 2019; PBL, 2018). In particular, having reviewed the findings of the IPBES regional and thematic assessments, Mastrángelo et al. (2019) emphasized that a limited understanding remains of the role that indigenous and local knowledge plays in sustaining the co-production of NCP. Other gaps include the relationships between multiple dimensions of NCP and good quality of life, the temporal dynamics of nonlinear social and ecological change, social–ecological feedbacks including how changes in people's preferences and quality of life influence governance and other indirect drivers, trade-offs between NCP, the influence of institutions in the social distribution of NCP and the effectiveness of governance systems to promote necessary transformations (Mastrángelo et al., 2019). Filling these gaps requires knowledge sharing across disciplines (e.g. modelling, natural and social science, ILK). We encourage the modelling community as well as all other researchers interested in furthering this component to engage with us in developing this body of work.

5 | CONCLUSION: REFRAMING NATURE FUTURES

As the IPBES Global Assessment (2019) has shown that Nature is declining globally at rates unprecedented in human history and makes it clear that transformative changes are needed to get us onto a more sustainable trajectory for the planet. Under the current socio-economic trajectory, the world will miss most of the Sustainable Development Goals (SDGs), and so we need to initiate changes in our economies, technologies and societies if we are to shift onto a more sustainable global development pathway (Naidoo & Fisher, 2020). The development of the NFF rests on the assumption that there is a critical need to develop positive nature-people scenarios for the future of our planet, particularly at such a moment when we need to act now to prevent irreversible environmental devastation with severe consequences to humanity (Steffen et al., 2018; Wyborn et al., 2020).

The year 2019 saw a diversity of perspectives on how to address the environmental challenges of our time. Examples include Extinction Rebellion[4] that argues that the global environmental crisis is an emergency marked by abrupt climate breakdown and mass extinctions and a global youth movement to avert a climate disaster, sparked by teenager Greta Thunberg, which resulted in mass climate protests and climate strikes by children around the world, referencing #FridaysfortheFuture[5] (Almeida, 2019). The World Economic Forum is advocating for a New Deal for Nature (Lambertini, Polman, & Børge, 2019), and the Global Deal for Nature has been proposed by the biodiversity research community (Dinerstein et al., 2019). Politicians are forming alliances with researchers and activists to propose interventions like The Green New Deal[6] led by United States Representative Alexandria

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Ocasio-Cortez and Senator Ed Markey. In the context of such diversity, the NFF allows for a standardized approach to appreciate a plurality of NCP over time and space and allows for a more nuanced approach to pathways development that is more relevant for actors operating within specific jurisdictions. Given the need for negotiating a new deal for nature in the post-2020 CBD agenda (Dinerstein et al., 2019; Lambertini et al., 2019), the NFF could create a space wherein a discussion on reversing the degradation of nature and declines in NCP could be held between actors as diverse as politicians and young climate activists.

All the necessary groundwork is currently being laid for the negotiations at CBD COP-15 on the post-2020 biodiversity framework and the global goals on nature to replace the Aichi biodiversity targets. As we navigate the next chapter in global biodiversity governance, the NFF makes a unique contribution towards improving the science–policy interface that can enable a better future for people and nature. However, this cannot be an isolated endeavour. We call on the research community to join us in testing and improving the framework in diverse contexts and where appropriate to use it in their work. In this way, together we can move towards a more desirable and hopeful future for people and the planet.

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CONFLICT OF INTEREST

The authors have no conflict of interest with regard to the publication of this manuscript.

AUTHORS' CONTRIBUTIONS

For the Auckland workshop, L.M.P., C.J.L., H.M.P. and G.P. conceived the ideas and designed methodology; C.J.L., R.A. and H.M.P. acquired funding; L.M.P., G.P., H.M.P., K.K.D., C.J.L., F.R., S.K.-V., R.A., N.K., S.C.R., J.H., E.d.B., T.L., A.G., facilitated the Auckland workshop; S.O., M.S., E.d.B., H.K., C.J.L. and J.J.K. collected and analysed the data from the workshop and subsequent stakeholder consultations and expert group meetings; L.M.P. led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT

All data are available in the cited reports and in Tables S1, S2 and S3 (source: Lundquist et al., 2017).

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ENDNOTES

[1] https://ipbes.net/diverse-values-valuation

[2] https://ipbes.net/sites/default/files/ipbes-7-inf-11_scenarios.pdf

[3] https://ipbes.net/core-indicators

[4] https://rebellion.earth/

[5] https://www.fridaysforfuture.org/

[6] https://theintercept.com/2019/04/17/green-new-deal-short-film-alexandria-ocasio-cortez/

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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