

A pluralistic Nature Futures Framework

Authors:

Lundquist, Carolyn J., National Institute of Water & Atmospheric Research, Hamilton; Institute of Marine Science, University of Auckland, New Zealand, +64-7-859-1866, carolyn.lundquist@niwa.co.nz, 0000-0002-2101-7237

Pereira, Henrique Miguel, German Centre for Integrative Biodiversity Research (iDiv), University Halle-Wittenberg, Am Kirchtor 1, 06108 Halle (Saale), Leipzig, Germany; CIBIO/InBio, Centro de Investigação em Biodiversidade e Recursos Genéticos, Laboratório Associado, Universidade do Porto, Campus Agrário de Vairão, 4485-661 Vairão, Porto, Portugal, hpereira@idiv.de, 0000-0003-1043-1675

Peterson, Garry D., Stockholm Resilience Centre, Stockholm University, Sweden, +46 73-707 85 92, garry.peterson@su.se, 0000-0003-0173-0112

Karlsson-Vinkhuyzen, Sylvia, Public Administration and Policy Group, Wageningen University, The Netherlands, +31317 4 82133, sylvia.karlsson-vinkhuyzen@wur.nl, 0000-0001-7632-8545

Pereira, Laura, Centre for Food Policy, City University of London, +447765696614, Pereira.laura18@gmail.com, Centre for Complex Systems in Transition, Stellenbosch University, South Africa, 0000-0002-4996-7234

Acosta, Lilibeth A., Department of Community and Environmental Resource Planning, University of the Philippines in Los Banos (UPLB) and Global Green Growth Institute (GGGI), Seoul, +82 10 95300477, lilibeth.acosta@t-online.de, 0000-0002-0733-3751

Akcakaya, H. Resit, Stony Brook University, Stony Brook, New York 11794 USA, Tel: 1-631-632-8605, Resit.Akcakaya@stonybrook.edu, 0000-0002-8679-5929

Cheung, William, The University of British Columbia, Vancouver, British Columbia, Canada, +1 604-827-3756, w.cheung@fisheries.ubc.ca, 0000-0001-9998-0384

Davies, Kathryn K. National Institute of Water & Atmospheric Research, Hamilton, New Zealand kate.davies@niwa.co.nz, 0000-0002-8979-8295

den Belder, Eefje. IPBES Technical Support Unit Scenarios and Models, PBL Netherlands Environmental Assessment Agency, the Netherlands, Eefje.denBelder@pbl.nl 0000-0003-2480-5148

Ferrier, Simon, CSIRO Land and Water, Canberra, ACT, Australia, +61 2 6246 4191, Simon.Ferrier@csiro.au, 0000-0001-7884-2388

Greenaway, Alison, Manaaki Whenua Landcare Research, Auckland, New Zealand, GreenawayA@landcareresearch.co.nz, 0000-0003-2288-8621

Hauck, Jennifer, CoKnow Consulting - Coproducing Knowledge for Sustainability, Mühlweg 3, 04838 Jesewitz, German, +4915775765800, jennifer.hauck@cknow.de, 0000-0002-1614-9657

Kim, HyeJin, German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Deutscher Platz 5e, 04103 Leipzig, Germany, hyejin.kim@idiv.de, +49 341 9733111, 0000-0003-1187-6414

Nicholas King, Research Unit for Environmental Science & Management, North-West University, Potchefstroom, South Africa, nking@gecko-net.com, 0000-0002-9624-1356

Kolomytsev, Grygoriy. I.I. Schmalhausen Institute of Zoology, National Academy of Sciences, Ukraine. g.kolomytsev@gmail.com, 0000-0002-0747-8600

Kuiper, Jan, Stockholm Resilience Centre, Stockholm University, Sweden, jan.kuiper@su.se, 0000-0002-6655-9355

Metzger, Jean Paul, Department of Ecology, University of São Paulo, Rua do Matão, 321, trv. 14, 05508-090, São Paulo, SP, Brazil, jpm@ib.usp.br, +551130917564, [0000-0002-0087-5240](https://orcid.org/0000-0002-0087-5240)

Ninan, Karachepone N., Centre for Economics, Environment and Society, India. ninankn@yahoo.co.in, 0000-0002-1633-5361

Okayasu, S. IPBES Technical Support Unit Scenarios and Models, PBL Netherlands Environmental Assessment Agency, The Hague, the Netherlands, sana.okayasu@pbl.nl, +31611102012, 0000-0002-6534-0458

Palomo, Maria Gabriela. Coastal Ecosystems Lab, Natural History Museum of Argentina. CONICET. Av. Angel Gallardo 470 CP1405DJR. C.A.B.A. Argentina. +541159369373, mariagapalomo@gmail.com, 0000-0002-9102-1282

Pichs-Madruga, Ramón. Centro de Investigaciones de la Economía Mundial (CIEM). Calle 22 No. 309, entre 3ra y 5ta Avenida, Miramar, Playa, Havana, CUBA: +5372042507, rpichsciem@ceniai.inf.cu / rpichs@ciem.cu, 0000-0002-0955-2624

Ravera, Federica, Chair in Agroecology and Food Systems, Universitat de Vic – Universitat Central de Catalunya (UVic-UCC), C. de la Laura, 13, 08500 Vic, Spain E-mail: Federica.ravera@uvic.cat, 0000-0001-6282-6236

Rondinini, Carlo, Global Mammal Assessment Program, Department of Biology and Biotechnologies, Sapienza University of Rome, I-00185 Rome, Italy, carlo.rondinini@uniroma1.it, 0000-0002-6617-018X

Sathyapalan, Jyothis. National Institute of Rural Development and Panchayati Raj, India, jyothis.nird@gov.in +91 9949531416, 0000-0002-0220-1063

Schoolenberg, Machteld A. IPBES Technical Support Unit Scenarios and Models, PBL Netherlands Environmental Assessment Agency, The Hague, the Netherlands. machteld.schoolenberg@pbl.nl, +31611102012, 0000-0002-8940-0291

Alkemade, Rob. IPBES Technical Support Unit Scenarios and Models, PBL Netherlands Environmental Assessment Agency, The Hague, the Netherlands; Environmental Systems Analysis group, Wageningen University, Rob.Alkemade@pbl.nl, +31 629510692, 0000-0001-8761-1768

Main Text:

The primary international process to protect the diversity of life on Earth is likely to fail to achieve most of its 2020 goals - the Aichi Biodiversity Targets, which the Convention on Biological Diversity (CBD) set to enable effective and urgent action to halt the loss of biodiversity (1, 2). Global coordination and innovative policies and tools at all governance levels are required to reverse ongoing declines in biodiversity and ecosystem services on which humans depend. Many of nature's contributions to human society are difficult to quantify, including cultural and societal recognition of nature for nature's sake, and the socio-cultural dependence of humans on nature. These relationships with nature frame the storylines that motivate society to act to conserve nature, thus they should serve as the foundation for the next iteration of global biodiversity strategies and goals.

The CBD is developing a post-2020 strategy that aims to achieve the vision of “Living in harmony with nature” in a world in which *“biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all*

people” (UNEP/CBD/SBSTTA/21/2 2017)¹. The post-2020 biodiversity negotiations provide the opportunity to develop new approaches to the design of scenarios and targets that improve upon shortcomings of conventional approaches. Ambitious transformations are required to address declines in biodiversity, worsening environmental health, and other manifestations of negative futures (1). Here, we propose a novel framework for recognizing the multiplicity of relationships between people and nature when developing scenarios to inform agenda setting and policy formulation. Our approach facilitates inclusion of the social, political, and cultural dimensions of pathways that enable or constrain the realization of positive nature futures.

Scenarios: envisioning and comparing alternative futures for nature

Scenarios are an important tool to assess the feasibility and implications of possible futures (3, 4). The development of the CBD’s Strategic Plan for Biodiversity 2011-2020 was supported by scenario analysis, and scenarios are likely to inform development of its post-2020 global biodiversity framework. Scenarios have also been widely used in global environmental assessments, such as those conducted by the Millennium Ecosystem Assessment, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Intergovernmental Panel on Climate Change (IPCC), the United Nations Environment Programme, and for local and regional environmental assessments (3, 5).

Conventional scenario approaches are not well suited to addressing the diversity of potential nature futures. Existing global scenarios and commonly used models (e.g. Integrated Assessment Models) underemphasize the dynamic and adaptive qualities of nature, and typically lack processes such as trophic interactions, species migrations, and social-ecological feedbacks between nature and people (6). Typically, biodiversity and ecosystem services are considered only as endpoints, acted on by societal and environmental drivers within a fixed set of contrasting socio-economic scenarios, rather than as diverse and dynamic system components interacting with other components of the natural-social-economic system, and therefore with people’s values, in a variety of ways across time and space. In climate scenarios, for example, a single positive future, such as limiting warming to 1.5°C, is often argued as desirable; however, stakeholders can have contrasting preferences for how nature should be managed within this future. Ignoring differences in nature preferences may create conflicts, such as the establishment of protected areas that conflict with indigenous land rights or local co-management approaches to hunting, fishing & livestock grazing. Developing scenarios that consider the multiplicity of desirable relationships with nature requires a fundamentally novel approach.

Nature Futures Framework

Here, we present the Nature Futures Framework (NFF) as a foundation for developing scenarios of positive futures for nature, to help inform assessments of policy options across multiple scales. The NFF allows exploration of a plurality of desirable futures with context- and socio-culturally specific policy and management options. This framework contrasts with existing scenarios examining a fixed set of contrasting futures reflecting uncertainties in socio-economic development pathways (e.g. Shared Socioeconomic Pathways) or different levels of ambition regarding a single desirable target (e.g. the relative concentration pathways for climate change) (7). The framework nevertheless builds on previous global scenario exercises, as well as approaches designed to create more transformative scenarios, in particular the ‘Seeds of a Good Anthropocene’ Project (8).

¹ UNEP/CBD/SBSTTA/21/2 (2017) Scenarios for the 2050 Vision for Biodiversity. <https://www.cbd.int/doc/c/4a22/3eba/a499b54091a1c1e22bb7b54e/sbstta-21-02-en.pdf> (Accessed 2019-01-31).

The NFF places relationships between people and nature at its core. Because people relate to nature in multiple ways, there are a wide variety of desirable nature futures, with different goals and visions which can be synergistic or in conflict with one another. The NFF was informed by a visioning exercise with diverse stakeholders including indigenous peoples, the private sector, civil society organizations, decision-makers, and scientists (9). This exercise generated seven positive future visions for nature (see Supplementary Information), which were further developed and assessed at participatory workshops and stakeholder consultations hosted by the IPBES Expert Group on Scenarios and Models.

There are many dimensions of the relationships between people and nature represented in these visions, and in other similar studies, and the NFF is organized around three main perspectives, abbreviated as Nature for Nature, Nature for Society, and Nature as Culture (Figure 1). These perspectives equate broadly with those proposed previously in similar typologies of how people value nature – e.g. “intrinsic value”, “instrumental value” and “relational value” in the typology of Pascual et al. (10) and Chan et al. (11); or “living with nature”, “living from nature” and “living in nature” in the typology of O’Neill et al. (12) and Kenter (13). We focus on positive relationships with nature, and do not include relationships that are solely for profit, are negative (i.e. fear, danger, disease) or are dismissive or indifferent to nature.

In the Nature for Nature perspective, people view nature as having intrinsic value, and value is placed on the diversity of species, habitats, and ecosystems that form the natural world, and nature’s ability to function autonomously. It is widespread in many societies and has dominated much of the original conservation movement’s concern about the extinction crisis and the protection of wilderness (1, 2). It is currently the primary motivation for Aichi targets on protected areas and species extinction reduction, and for future visions such as Half Earth (14) or restorative management initiatives such as rewilding (15).

The Nature for Society perspective highlights the utilitarian benefits that nature provides to people and societies. This view is reflected in concepts such as ecosystem services, natural capital, green infrastructure, and nature-based solutions which exemplify nature as a provider of services to society (10). Ecosystem service science has developed a wide variety of approaches to quantify benefits that people receive from nature, such as food production, water filtration, and recreation, as well as considering how these benefits flow to different beneficiaries. This perspective has grown in importance in environmental policy over the last two decades (1) and is present in Aichi targets around enhancing benefits from biodiversity.

Nature as Culture highlights perspectives of nature and people in harmony, where societies, cultures, traditions and faiths are intertwined with nature in shaping cultural landscapes. Relational values of nature are emphasized in cultural geography and social-ecological systems research, and exemplify spiritual and other non-material nature relationships (11). The Nature as Culture perspective is not limited to indigenous knowledge systems, being increasingly recognized worldwide, for example, with initiatives that promote reconnecting with nature within urban and rural landscapes. However, it is underrepresented in the Aichi targets and in the indicators used to assess their progress (2).

From the Nature Futures Framework to Scenarios

While these three types of nature perspectives are deeply embedded within different streams of traditions, scholarship and policy, bringing them together in a shared framework is a novel, and to some extent radical, approach to developing scenarios of positive futures for nature. These nature perspectives can be visualised using a triangular diagram (Figure 1), in which each vertex represents a dominant nature perspective, while the interior of the triangle represents overlaps between these idealized perspectives. The seven positive future nature visions developed by stakeholders (9) can be

mapped into this diagram, with each one representing a particular combination of emphasis in each perspective (Figure S2).

The state of the planet, a country, or a local area can be mapped into this diagram when assessing pathways to positive futures. Target-seeking scenarios can be developed to identify pathways and actions that move social-ecological systems away from their current degraded state (Figure 2). Scenarios can be parameterized using models and expert knowledge to assess the impacts of policies and actions on direct drivers (e.g. fisheries management) and indirect drivers (e.g. change in diets) (4).

Advantages of the Nature Futures Framework

The novelty of the NFF is its ability to bring the diversity of perspectives that people have for nature into a unified approach. This tool can be used by the CBD and other processes to explore solution-focussed plans, policies and practices that consider what types of nature people desire, rather than what type of nature will result from external economic or climatic drivers. The world needs visions and scenarios of desirable futures to stimulate action towards achieving them (8), and the NFF integrates the relationships between people and nature in a tractable and useable way. Furthermore, it focuses on reciprocal relationships between people and nature rather than only people's impact on nature, or nature's impact on people.

The NFF explicitly recognizes that multiple relationships between people and nature exist. Most people do not hold extreme preferences, and would place their preferences within the triangular framework rather than at a vertex or edge (Figure 1). The framework embraces pluralism in how people relate to nature, helping to bridge and understand conflicts that currently frustrate conservation efforts, while simultaneously allowing people to understand, identify and articulate commonalities, shared values, and opportunities for collaboration and collective action. This pluralism allows the framework to be applied across diverse social, geographical, and sectoral contexts.

Research and policy opportunities to support implementation of the NFF

Further developments are required to enable effective implementation of the NFF. Substantial knowledge and capability exists to model scenarios from a Nature for Society perspective, such as provisioning and regulating ecosystem services (4), but less attention has been given to cultural ecosystem services and to linkages between biodiversity and ecosystem services. Similarly, some aspects of Nature for Nature can be readily quantified (e.g. species ranges, distributions) (4), but significant gaps remain (e.g. ecosystem dynamics, restoration benefits). The importance and pervasiveness of values that underpin Nature as Culture are recognised; however, quantitative models and indicators for addressing this perspective are lacking. A potential starting point is the emerging paradigm of participatory place-based scenarios (5).

Development of multi-scale models, datasets, and effective participatory tools and processes to support the NFF requires mobilisation of the research community to align scenarios and models with this framework. New modelling approaches are required to account for multi-scale functionality, and improve upon the traditional driver-pressure-state-impact cascade to fully incorporate social-ecological feedbacks and tipping points (6), recognising that changes in the state of nature (e.g. stock depletion) may change the social dynamics (e.g. decrease demand) when new policies are implemented. Developments should be tightly coupled with co-design by relevant stakeholders of suitable targets and indicators for each manifestation of nature preferences across scales. Integration across scales requires quantification of contributions of actions across scales, such as shifts in consumption patterns, and alternative governance frameworks that drive transformative changes toward desired positive futures.

The NFF represents a substantial departure from conventional approaches to scenario development. It offers a platform for developing positive nature futures, which embraces pluralism and inclusivity in knowledge systems and worldviews to inform novel solutions, more appropriate targets and monitoring, and improved implementation. By putting nature at the center of desirable future scenarios, the framework focuses attention on ensuring a functioning biosphere, and enables bridging discussions amongst diverse stakeholders. The NFF can help align and mobilize diverse activities to embrace and motivate transformative change to bend the curve of biodiversity loss (1), and support the coherent policy and transformational change necessary to achieve the 2050 Vision for Biodiversity.

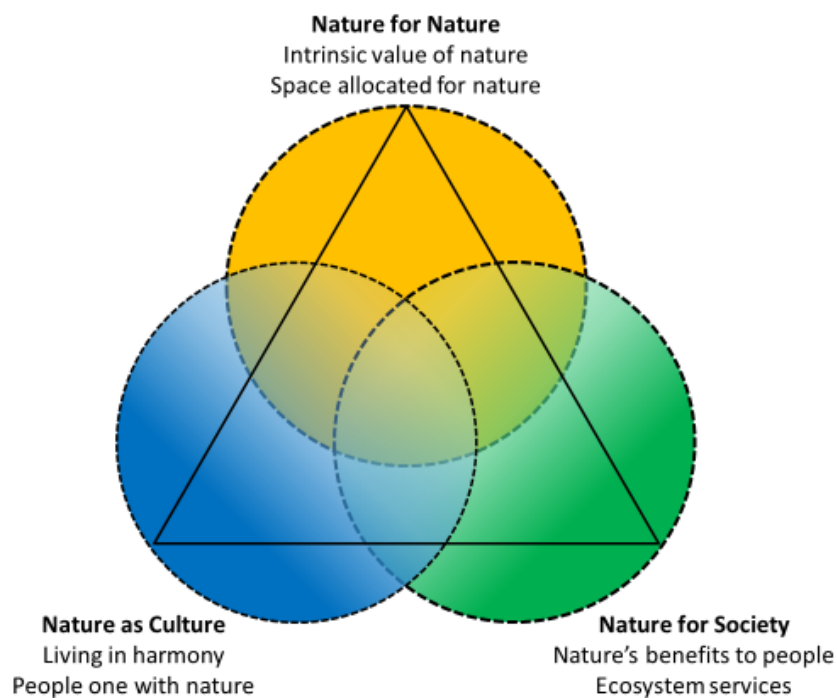


Figure 1. Pluralistic Nature Futures Framework to capture multiplicity of relationships between people and nature: Nature as Culture (blue) where society lives in harmony with nature, Nature for Society (green) where utilitarian values for nature dominate, and Nature for Nature (orange) where intrinsic values for nature, its species, habitats, and ecosystems, are given higher value than benefits to humans.

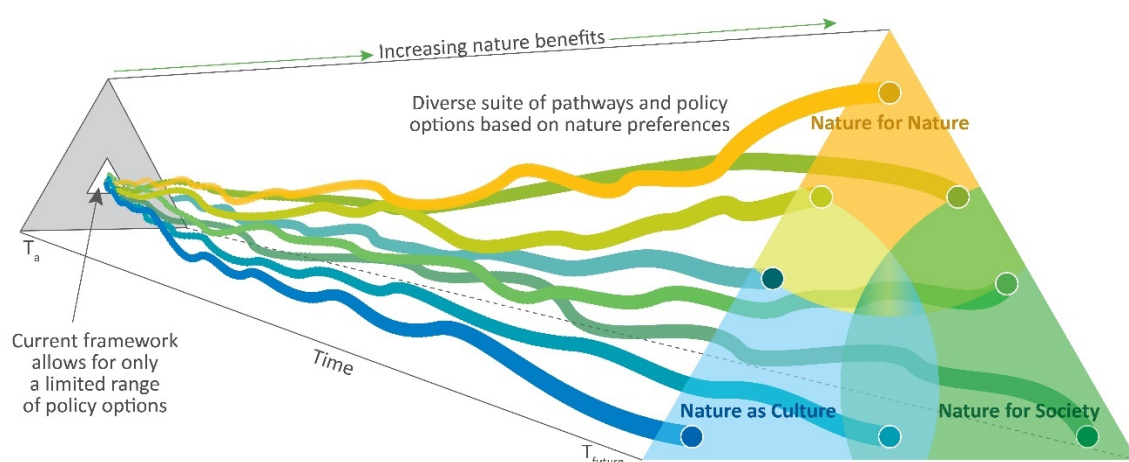


Figure 2: Conceptual description of how the framework can be used to develop future biodiversity scenarios, where pluralistic positive future visions are possible through the implementation of

different pathways and policy options that highlight different nature preferences. The current degraded state of nature emphasised a conventional scenarios approach where the suite of policy options and their resulting nature futures, and incorporate of preferences for nature are limited (smaller triangle within left triangle). The Nature Future Frameworks allows for a diverse suite of positive futures, represented by a wider set of possible states that provide benefits to nature across one or more dimensions of these nature perspectives (right triangle).

References


1. G. M. Mace *et al.*, *Nature Sustainability* **1**, 448 (2018/09/01, 2018).
2. D. P. Tittensor *et al.*, *Science* **346**, 241 (October 10, 2014, 2014).
3. E. Nicholson *et al.*, *Trends Ecol. Evol.* **34**, 57 (2019/01/01/, 2019).
4. IPBES, "The methodological assessment of scenarios and models of biodiversity and ecosystem services" (Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany, 2016).
5. E. Oteros-Rozas *et al.*, *Ecol. Soc.* **20**, (2015).
6. I. M. D. Rosa *et al.*, *Nature Ecology & Evolution* **1**, 1416 (2017/10/01, 2017).
7. D. P. van Vuuren *et al.*, *Global Environ. Change* **42**, 148 (2017/01/01/, 2017).
8. E. M. Bennett *et al.*, *Front. Ecol. Environ.* **14**, 441 (2016).
9. C. Lundquist, 74 international co-authors, "New visions for nature and nature's contributions to people for the 21st century" (National Institute of Water & Atmospheric Research Ltd. , Wellington, New Zealand, 2017).
10. U. Pascual *et al.*, *Current Opinion in Environmental Sustainability* **26-27**, 7 (2017/06/01/, 2017).
11. K. M. A. Chan, R. K. Gould, U. Pascual, *Current Opinion in Environmental Sustainability* **35**, A1 (2018/12/01/, 2018).
12. J. O'Neill, A. Holland, A. Light, *Environmental values*. (Routledge, 2008).
13. J. O. Kenter, *Ecosystem Services* **33**, 40 (2018/10/01/, 2018).
14. H. Locke, *Parks* **19**, 9 (2013).
15. A. Perino *et al.*, *Science* **364**, eaav5570 (2019).

Supplementary Material

Seven nature futures visions were created at a workshop with stakeholders and experts on 4-8 September 2017 in Auckland, New Zealand (Figure S1, Table S1). A total of 73 participants from inter-governmental organizations, national government organizations, non-governmental organizations, academia and the private sector, from 31 countries, and with a range of sectoral expertise on biodiversity topics, from urban development to agriculture to fisheries, worked together in a visioning exercise. This creative visioning exercise was carried out based on a suite of participatory methods that were used to develop visions of alternative nature futures (1). The workshop was broadly based on an approach developed by researchers in the Seeds of the Good Anthropocene Project (2, 3), using a suite of scenario building tools and techniques adapted from the Manoa Mash-up scenario building approach. First the participants identified a set of themes within which to develop the visions. Next, thematic groups identified the main trends for biodiversity and ecosystem services in each theme and a set of “Seeds” of emerging initiatives leading to positive futures for nature. Future Wheels were developed by each thematic group to explore the implications of each seed across a range of sectors. The Three Horizons Framework was then used to develop a pathway analysis of which changes in external factors (e.g. STEEP: Social, Technological, Economical, Environmental, and Political) must occur to transform the current state into the desirable future. Narratives were then built for the visions emerging from each group. Finally, commonalities of visions across the groups were identified, and the regional relevance of each vision for different parts of the world was assessed.

Additional workshops and focus groups were held to socialise and iterate the visions, resulting in the development of the Nature Futures Framework through analysis of the seven visions across different dimensions and drivers (4). Comparison of how these visions were differentiated across different drivers facilitated the emergence of the three nature perspectives (Nature for Nature, Nature as Culture, Nature for Society), and resulting development the Nature Future Framework (Figure 1). As a further test of the relevance of the framework, the seven visions, focusing on their key defining elements, were placed within the framework, showing how these seven positive nature future visions reflect a diversity of nature perspectives, and that different policy and management actions are required to achieve each of these visions (Figure S2).

Table S1. Summary descriptions of the Nature Futures visions developed at 2017 stakeholder workshop in Auckland, New Zealand (1). (Illustrations: Mary Brake, Reflection Graphics; Dave Leigh, Emphasise Ltd.; Pepper Lindgren-Streicher, Pepper Curry Design).

Nature-based Inclusive Prosperity 	This vision is based on natural resources that sustain richly diverse cultures, societies and nature into the future. The vision illustrates a world based on restructured global governance and institutional mechanisms that include externalities to incentivise sustainable resource use. Nature-based inclusive prosperity is based on three main components or seeds. The first component envisions a global network of self-governing and self-sustaining community-based economies with an equitable (in terms of nature, gender, religion, race, age or cultural group) approach to sustainable natural resource use and management. The second component comprises national and regional development plans with key ecological objectives that complement local economic activities, sustains and supports the wellbeing of all sectors of society and contributes to reducing inequalities. Development plans would be underpinned
---	---

	<p>by national systems of natural resource use taxation, associated biodiversity and ecosystem services monitoring and assessment systems, environmental education, public awareness programs and participatory planning. The foundations for these developments are framed within a global agreement to replace the “GDP growth” goal with new paradigms for the wellbeing of people and nature, including placing the rights of nature at the centre of the international legal system (along with other universal and inalienable rights). Mechanisms to support this paradigm shift include metrics for biodiversity, quality of life and natural resource use as measures of GDP. Further, an international natural resource consumption taxation system is developed and utilized to redistribute funds to a common international funding pool to alleviate poverty, support environmental management, and provide venture capital for sustainable technological innovation. Education and awareness building are central to implementing the vision.</p>
<p>Sustainable Food Systems</p> 	<p>In this vision, global food production systems are re-envisioned, emphasizing sustainable supply chains and benefit sharing between producers, traders, transporters and retailers, grounded on biodiversity-based food production and which support local and indigenous communities. Sustainable supply chains provide long-term agreements between producers, traders, transporters, and retailers, and support the implementation of sustainable practices (by training and transferring knowledge and technical innovations), balance prices, and help to stabilize the income of rural communities. Biodiversity-based food production occurs at agro-ecosystem, landscape and seascape levels. Accessible reciprocal agreements for water and other ecosystem services are also key elements of this vision. Sustainable food production includes efficient use and management of resources and inputs, enabled through production of highly diverse food sources in landscapes and seascapes. Clean technologies and energy will allow for a low ecological footprint, and enhanced liveability of rural areas (alongside sustainable cities and communities). There will be zero hunger and reduced inequalities. Nature is the foundation ensuring an optimal delivery of ecosystem services and goods (including maintenance and use of genetic diversity and clean and sufficient water). Land used for production and resource extraction is planned and managed sustainably within a landscape matrix that equally supports nature and biodiversity. Incentives for sustainable farming/food production and innovations support transition from the current state to these sustainable food systems. Inclusive and effective governance in all settings (local, national, international) will open debates over resource use to wider social, environmental (value of nature), and ethical interests. Education/training, public (consumer) awareness programs (environmental, ecological and nutrition consciousness) as well as technical protocols for the production of food, will lay the foundations for pathways of change. Food production provides decent employment conditions to those who practice it,</p>

ReFooding and ReWilding the Urban Rural Flows



in an economically and physically safe and healthy environment.

This vision illustrates a world where urban and rural dwellers reconnect with nature, reconcile their interests and assist each other in improving quality of life in the cities and valuing the countryside. Enhanced urban-rural flows of biodiversity and ecosystem services are achieved by a locally contingent combination of three elements: 1) reconnecting to nature through enhanced food systems (ReFooding); 2) reconnecting to nature by bringing nature back to cities and rewilding the countryside (ReWilding); and 3) reconnecting to nature through improved governance (ReGoverning). ReFooding includes innovative on-line platforms to share food knowledge and promote sustainable eating habits (e.g. seasonal and local food choices) and social enterprises promoting greater community cohesion through food (e.g. farmer markets and food swaps). Multiple-use landscapes, such as agro-forestry systems, safeguard agrobiodiversity while providing diverse provisioning, regulating and cultural services. Society appreciates this “tamed” nature which stimulates innovative entrepreneurship across urban-rural landscapes and localized ecosystem service flows (e.g. closing the nitrogen cycle at the landscape scale). ReWilding uses high-tech solutions to free up space for nature in the countryside (e.g. sustainable intensification of agriculture) and on urban design solutions to bring nature into the cities (e.g. green roofs as wildlife corridors and natural ecosystem dynamics allowed in city parks). The countryside is rewilded to restore natural processes to promote the return of wildlife, and to promote opportunities for nature-based economies (e.g. wildlife based tourism). In landscapes where ReWilding dominates, ecosystem services are connected across large scales and new values are entrenched in society that adapts to live in harmony with “wild” nature. ReGoverning places biodiversity and ecosystem services at the center of political agendas at multiple scales (local, regional, global). Biodiversity and ecosystem services performance metrics are used to implement fiscal flows between ecosystem services consumers and producers, reducing inequity between regions and individuals.

Healthy Social-Ecological Freshwater Systems



This freshwater-centric vision is a world where innovative technologies and circular economies support the most efficient water use and re-use at local scales. This vision presents a global framework that recognizes the direct dependency of humanity on freshwater as arguably our most limiting natural resource and provisioning ecosystem service essential to all human endeavour. In this world rivers would be accorded legal rights as living systems; socio-cultural connections would be re-established and the decision-making regarding resource use and management decentralised locally to all catchment stakeholders in dedicated catchment management fora. Water use would be micro-scale, optimally efficient and recycled, i.e. all return flows would be in as, or better quality, than prior to abstraction, as part of an overarching circular economy paradigm, with pollution treated at source or prevented, by the polluter. As such there would be no

	<p>such thing as polluted ‘wastewater’ and freshwater biodiversity and productivity of, for example, local fisheries, would be actively restored. Further, in recognizing the interdependency of our energy and water systems and needs, this world also encompasses an interconnected rapid shift to micro-scale renewable energy systems and complete phase-out of all fossil fuel-based energy, as well as hydropower due to its disruption of free-flowing river systems. With a rapidly urbanizing humanity, this world recognizes emerging and created (e.g. artificial wetlands) novel ecosystems in urbanizing environments, including urban agriculture, and the complete redesign via ‘green infrastructure’ of ‘green cities’, and active enhancement of the role of urbanized rivers in biodiversity protection and ecosystem connectivity. The ‘greening’ of cities plays a major role in enhancing human health, wellbeing and livelihoods in this world.</p>
<p>A Tasty World with Values</p> 	<p>This vision illustrates a world where values of reciprocity, harmony and relationality drive human relationship with nature at all levels of human organization. Humanity is continuously enriching the flourishing of nature and able to sustainably reap its abundant bounties. Biological and cultural diversity are co-conserved and co-managed without being enclosed in protected areas. Every child appreciates the cultural and spiritual values of nature and every human has a relation to place, feels part of nature and a community, has a deep awareness of interrelations between their own place and actions with places far away in space and time and learns to act accordingly through a lifelong intergenerational educational process. In this vision food production is dominated by bio-culturally diverse and sovereign local food systems along the continuum of rural to urban. Food production occurs under principles of respect and enhancement of cultural and biological diversity, creating a food production system highly resilient towards environmental changes. Landscapes will in this world be connected locally and over long distances. Considerable exchange of information and products occurs at both local and international scales. Trade operates under principles that consider social-ecological justice. It is a world where there is respectful sharing among diverse knowledge systems and including their ways of looking at and valuing the world. Such sharing is based on the recognition of the valuable contribution of all humans both to the generation of knowledge and to the wise application of technology. In this world, relationships of domination and inequity (including epistemological domination, gender and social inequity) have been transformed into relationships of mutual respect and justice. A rich diversity of governance systems related to place and context share central value foundations of obligation and responsibility towards nature and universal recognition of indigenous peoples’ sovereignty over their lands and knowledge systems.</p>
<p>Dancing with nature</p>	<p>This vision illustrates a world where nature is at the center, and human societies both accommodate and benefit from natural environmental fluctuations. It focuses on dynamic nature,</p>



meaning ecological processes that operate largely independent of human control. In this vision, humanity has reconfigured itself to accommodate and steward these shifting processes. Dynamic societies and infrastructure emerge, with technological innovations that enable people and nature to adapt to the challenges of the Anthropocene. People have given nature space, to connect at multiple scales, in order to allow it continually to change and evolve. Where appropriate, people have restored natural processes, such as seasonal migrations, and returned missing species to ecosystems to allow plants and animals to dynamically reshape ecological structures and processes. Human infrastructure and civilization is designed to accommodate rather than regulate the living and non-living fluctuations of nature, allowing space for dynamic natural processes such as flooding to occur without costly damage occurring to human populations (e.g. Rotterdam's layout allowing "room for the river"). Ecological connectivity is restored or increased across human landscapes, for example wildlife corridors and riparian buffers, which allow animals to move and natural dynamics to occur within and across human dominated ecosystems. Innovative genetic technologies that allow people to modify and create new types of genetic diversity, such as CRISPR, are used to increase the adaptive capacity of populations to enable nature to thrive in a world transformed by humanity. Many social changes are required for these examples to grow and spread and they are not without tensions. The vision anticipates expansion of transnational agreements and organisations, such as the Arctic Council, to address social-ecological issues across national borders and create transnational spaces for nature, in the deep ocean and mountain areas, that enable rewilding while providing economic and human opportunity.

Healthy Oceans, Happy Communities



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 food production. The oceans and coasts are full of life, and biodiversity and ecosystem services provision in oceans and coasts are sustained. A radical guardian role is adopted by governments and businesses, which commit to 500-year strategies, accounting for the full life cycle of their products. The high seas are closed to fishing and the coastal zones are managed sustainably (ban of unsustainable fishing practices). Inputs from the land are well-managed (including cumulative effects and full bans of single-use plastics). Indigenous and local communities are actively involved in the management and restoration of the coasts (including, for example, participating in community coral gardening). There is an equitable sharing of benefits from oceans and coasts (e.g. across gender, race, religion, age). New, sustainable technologies are developed to produce energy, which has helped to mitigate

climate change impacts and its consequences for the ocean. New technologies (e.g. artificial fish growing) are also helping to feed vast populations, while at the same time the rise of vegetarian/vegan movements have further reduced the pressures on ocean resources. In this future, society has respect for ocean life, rights and welfare and treats it as 'if it feels pain'. Children are taught of the intrinsic value of the ocean and intergenerational environmental knowledge is widely shared.



Figure S1. Nature Futures visions developed at 2017 stakeholder workshop in Auckland, New Zealand (1). (Illustrations: Mary Brake, Reflection Graphics; Dave Leigh, Emphasise Ltd.; Pepper Lindgren-Streicher, Pepper Curry Design).

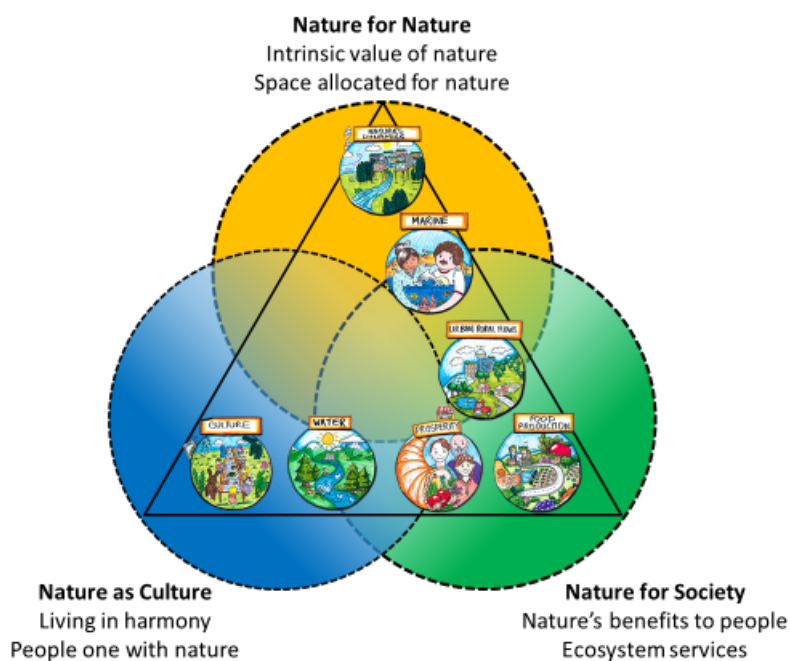


Figure S2. Auckland Nature Futures visions (1) mapped onto the Nature Futures Framework. (Illustrations: Mary Brake, Reflection Graphics; Dave Leigh, Emphasise Ltd.; Pepper Lindgren-Streicher, Pepper Curry Design).

Supplementary Information References

1. C. Lundquist, 74 international co-authors, "New visions for nature and nature's contributions to people for the 21st century" (National Institute of Water & Atmospheric Research Ltd., Wellington, New Zealand, 2017).
2. E. M. Bennett et al., *Front. Ecol. Environ.* 14, 441 (2016).
3. L. M. Pereira, T. Hichert, M. Hamann, R. Preiser, R. Biggs, *Ecol. Soc.* **23**, (2018).
4. M. Schoolenberg *et al.*, "Report on the Workshop 'Next Steps in Developing Nature Futures'" (PBL Netherlands Environmental Assessment Agency, The Hague, The Netherlands, 2018).