Ecosystem Services

Global Issues, Local Practices

Sander Jacobs, Nicolas Dendoncker, Hans Keune

Ecosystem Services

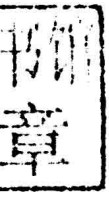
Global Issues, Local Practices

Edited by

Sander Jacobs
Research Institute for Nature and Forest (INBO);
University of Antwerp. Department of Biology,
Ecosystem Management Research Group (ECOBE)

Nicolas Dendoncker
Department of Geography, University of Namur (UNamur).
Namur Research Centre on Sustainable Development (NAGRIDD).
Namur Centre for Complex Systems (naXys)

Hans Keune
Belgian Biodiversity Platform;
Research Institute for Nature and Forest (INBO);
Faculty of Applied Economics – University of Antwerp;
naXys, Namur Center for Complex Systems – University of Namur



ELSEVIER

AMSTERDAM • BOSTON • HEIDELBERG • LONDON
NEW YORK • OXFORD • PARIS • SAN DIEGO
SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO

Elsevier
525 B Street, Suite 1900, San Diego, CA 92101-4495, USA
225 Wyman Street, Waltham, MA 02451, USA

First edition 2014

Notice
No responsibility is assumed by the publisher for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions or ideas contained in the material herein. Because of rapid advances in the medical sciences, in particular, independent verification of diagnoses and drug dosages should be made.

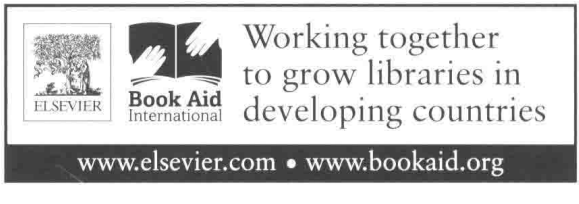
Library of Congress Cataloging-in-Publication Data
A catalog record for this book is available from the Library of Congress

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Printed and bound in China

14 15 16 17 18 10 9 8 7 6 5 4 3 2 1

ISBN: 978-0-12-419964-4



Ecosystem Services

Foreword

Ecosystem services and their largely invisible values, so vital to recognize for sustainability, have at last begun to percolate into policies. *The Economics of Ecosystems and Biodiversity* (TEEB) reports have added much-needed awareness and societal debate about how much our well-being, economy, and even survival depend on biodiversity and ecosystems. At a local level, better informed practices are being implemented in a variety of socioeconomic and ecological contexts, while, internationally, institutions such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) have emerged.

However, our world is still rapidly approaching and even crossing planetary boundaries, including climate, biodiversity, nitrogen and phosphorous concentrations, ocean acidification and freshwater scarcity. Economies worldwide are still headed in the wrong direction, leading to resource exhaustion, social disparities, and persistent poverty. Increasing climate disruptions may cause price volatility and loss of arable land, and the poor will suffer the most from these disruptions. Urgent changes are needed to effect sustainable resource use.

This book originated from a lively community of practice on ecosystem services in a highly urbanized European region, representative for many developed countries. Practitioners, nongovernmental organizations (NGOs), policy makers at different levels, and scientists from many disciplines have united to implement ecosystem service approaches. This book—a product of this community of practice—is a "proof of concept" of a transdisciplinary approach involving a broad range of stakeholders to improve and link up knowledge and practice internationally.

From their experiences, a strong and clear plea emerges to reorient ecosystem service research and practice, bringing it back to its "sustainability" roots: to account for boundaries and fairness more than with just lip service or introductory texts; to document, communicate, and cope with uncertainties; to adopt an inclusive and transparent approach; and to evaluate the real impacts of various measures and instruments on materials flows.

The debates presented here are fundamentally important and have repercussions for any ecosystem service research or practice. As we need immediate changes if we want to steer clear of planetary boundaries and avoid large natural disasters, we have to share experiences, knowledge, and debates widely, within and across communities of practice, locally and globally.

The editors rightly argue that ecosystem service research and practice should urgently aim at a more limited and fairer resource use supported by

transdisciplinary approaches and with real-life results. Their diverse contributions offer many practical lessons and tools to address the many challenges across a broad range of issues in assessing and managing ecosystem services.

In short, this book is a "must-read" for academicians conducting interdisciplinary ecosystem service research, practitioners and policy makers aiming to incorporate ecosystem services into their work, and students from the natural and social sciences. If ecosystem service practice is to live up to high expectations as well as urgent requirements to deliver sustainable resource use, the principles put forward in this book will have to be fully embraced.

Pavan Sukhdev

Pavan was Special Adviser and Head of UNEP's Green Economy Initiative, and lead author of their report "Towards a Green Economy." He was also appointed Study Leader for the G8+5 commissioned project on The Economics of Ecosystems and Biodiversity (TEEB).

Contributors

Alain Peeters RHEA Research Centre rue Warichet, Natural Resources, Human Environment and Agronomy (RHEA)

Anik Schneiders Research Institute for Nature and Forest (INBO)

Anil Markandya University of Bath, Department of Economics and International Development, United Kingdom and Scientific Director of Basque Center of Climate Change

Anne Teller DG Environment, European Commission

Anne-hélène Prieur-Richard DIVERSITAS, Reviewed by Francis Turkelboom (INBO); Belgian Biodiversity Platform; Research Institute for Nature and Forest (INBO); Faculty of Applied Economics – University of Antwerp; naXys, Namur Center for Complex Systems – University of Namur

Birgen Haest The Flemish Institute for Technological Research (VITO)

Cédric Chevalier Political advisor, Cabinet of the Walloon and the Wallonia-Brussels Federation Minister of Sustainable Development and Research

Conor Kretsch COHAB

Corentin Fontaine University of Namur (UNamur)

Dirk Van Gijseghem Flemish Ministry of Agriculture, Division for Agricultural Policy Analysis

Dirk Vrebos University of Antwerp, Ecosystem Management Research Group (ECOBE)

Dries Landuyt University of Ghent, Laboratory of Environmental Toxicology and Aquatic Ecology-AECO; Flemish Institute for Technological Research (VITO)

Erik Gómez-Baggethun Institute of Environmental Science and Technology, Universitat Autònoma de Barcelona; Social-Ecological Systems Laboratory, Department of Ecology, Universidad Autónoma de Madrid

Ferdinando Villa Basque Centre for Climate Change (BC3); IKERBASQUE, Basque Foundation for Science

Francis Turkelboom Research Institute for Nature and Forest (INBO)

Frederic Ghys Sustainability analyst

Frédéric Huybrechs Institute of Development Policy and Management (IOB), University of Antwerp

Gert Van Hecken Institute of Development Policy and Management (IOB), University of Antwerp

Glenn Deliège KU Leuven, Husserl-Archives, International Centre for Phenomenological Research

Guy Duke Environment Bank Ltd

Hans Keune Belgian Biodiversity Platform; Research Institute for Nature and Forest (INBO); Faculty of Applied Economics – University of Antwerp; naXys, Namur Center for Complex Systems – University of Namur

Heidi Wittmer Helmholtz Centre for Environmental Research—UFZ Division of Social Sciences, Department of Environmental Politics

Hilde Heyrman VLM

Ilse Simoens Research Institute for Nature and Forest (INBO)

Inge Liekens Flemish Research and Technology Organisation (VITO)

Jan Staes University of Antwerp, Ecosystem Management Research Group (ECOBE)

Jan Verboven Vlaamse Landmaatschappij regio West

Jeroen A.E. Panis Agency for Nature and Forests, Government of Flanders

Jim Casaer Research Institute for Nature and Forest (INBO)

Joachim H. Spangenberg Helmholtz Centre for Environmental Research—UFZ, Department Community Ecology

Johan Bastiaensen Institute of Development Policy and Management (IOB), University of Antwerp

John Gowdy Rensselaer Polytechnic Institute, Troy, New York

Joris Aertsens Flemish Research and Technology Organisation (VITO)

Jos Brils Senior adviser with Deltares in the area of sustainable management of natural resources; Co-Coordinator of the Dutch Community of Practice (CoP) on Ecosystem Services

Katrien Van der Biest University of Antwerp, Ecosystem Management Research Group (ECOBE)

Kelly Hertenweg DG Environment of Federal Public Service Health, Food Chain Safety and Environment

Kris Struyf Zwin Nature Centre, KUDDKE-HEIST

Kris Verheyen Forest and Nature Lab, Ghent University

Layla Saad Faun and Biotopes asbl

Leander Raes UG

Leen Franchois Research Department, Boerenbond

Leen Gorissen Unit Transition Energy and Environment, The Flemish Institute for Technological Research (VITO)

Leo De Nocker Flemish Research and Technology Organisation (VITO)

Leo Declercq Zwin Nature Centre, KUDDKE-HEIST

Leon C. Braat Alterra, Wageningen University and Research, Wageningen

Lieve Janssens Province of Antwerp, Department of Environment, Nature & Landscape Team

Linda Meiresonne Research Institute for Nature and Forest (INBO)

Lucette Flandroy DG Environment of Federal Public Service Health, Food Chain Safety and Environment

Maarten Stevens Research Institute for Nature and Forest (INBO)

Machteld Gryseels Brussels Environment, Direction Quality of the Environment and Nature Management Gulledelle

Marc Dufrêne ULG-GxABT

Marije Schaafsma University of East Anglia, Centre for Social and Economic Research on the Global Environment, England, United Kingdom

Marijke Thoonen Research Institute for Nature and Forest (INBO)

Martin Hermy KULeuven

Martin Sharman Independent expert, Avenue des Orangers

Nathalie Pipart Université Libre de Bruxelles, Institut de Gestion de l'Environnement et d'Aménagement du Territoire, Centre d'Etudes du Développement Durable

Nele Smeets Flemish Research and Technology Organisation (VITO)

Nicolas Dendoncker Department of Geography, University of Namur (UNamur). Namur Research Centre on Sustainable Development (NAGRIDD). Namur Centre for Complex Systems (naXys)

Olivier Beauchard University of Antwerp, Ecosystem Management Research Group (ECOBE)

Patrick Meire University of Antwerp, Ecosystem Management Research Group (ECOBE)

Paula Ulenaers Vlaamse Landmaatschappij regio West

Perrine Raquez University of Namur (UNamur)

Peter Goethals University of Ghent, Laboratory of Environmental Toxicology and Aquatic Ecology-AECO

Philippe C. Baveye Rensselaer Polytechnic Institute, Troy, New York

Pieter Vangansbeke Unit Transition Energy and Environment, The Flemish Institute for Technological Research (VITO); Forest and Nature Lab, Ghent University

Pim Martens ICIS, Maastricht University

Rik De Vreese VUB

Rob D'Hondt University of Ghent, Laboratory of Environmental Toxicology and Aquatic Ecology-AECO

Sabine Wallens DG Environment of Federal Public Service Health, Food Chain Safety and Environment

Sander Jacobs Research Institute for Nature and Forest (INBO); University of Antwerp. Department of Biology, Ecosystem Management Research Group (ECOBE)

Sarah Cornell Stockholm Resilience Centre

Saskia Van Gaever DG Environment of Federal Public Service Health, Food Chain Safety and Environment

Simon W. Moolenaar Programme Manager SKB, Chair of the SNOWMAN Network, Strategic consultant Environment & Sustainability at Royal Haskoning DHV

Steven Broekx Flemish Research and Technology Organisation (VITO)

Sylvie Danckaert Flemish Ministry of Agriculture, Division for Agricultural Policy Analysis

Tanya Cerulus Environment, Nature and Energy Department, Environmental, Nature and Energy Policy Division, Government of Flanders

Tom Bauler Université Libre de Bruxelles, Institut de Gestion de l'Environnement et d'Aménagement du Territoire, Centre d'Etudes du Développement Durable

Tom de Bie KU Leuven, Laboratory of Aquatic Ecology, Evolution and Conservation; Flemish Environment Agency (VMM), Catchment office Dijle-Zenne catchment

Wim Van Gils Policy Director, Natuurpunt

Wouter Van Reeth Research Institute for Nature and Forest (INBO)

Editorial for *Ecosystem Services—Global Issues, Local Practices*

No Root, No Fruit—Sustainability and Ecosystem Services

Sander Jacobs[1,2], Nicolas Dendoncker[3], and Hans Keune[4,5,6,7]

[1]Research Institute for Nature and Forest (INBO), [2]University of Antwerp. Department of Biology, Ecosystem Management Research Group (ECOBE), [3]Department of Geography, University of Namur (UNamur). Namur Research Centre on Sustainable Development (NAGRIDD). Namur Centre for Complex Systems (naXys), [4]Belgian Biodiversity Platform, [5]Research Institute for Nature and Forest (INBO), [6]Faculty of Applied Economics – University of Antwerp, [7]naXys, Namur Center for Complex Systems – University of Namur

The human species survives and prospers within well-defined planetary conditions. The concept of planetary boundaries [1] delimits this safe operating space with respect to the functioning of the Earth System. Since the 20th century, the Earth has entered a new epoch, the Anthropocene, where humankind constitutes the dominant driver of change to the Earth System as a global geological force in its own right [2], shifting the conditions beyond its own safe operating space ([3]; see also Chapter7).

Among several planetary boundaries being crossed today [1], ever-accelerating biodiversity loss is particularly serious, given the vital importance of biodiversity for sustaining ecosystem functioning and preventing ecosystems from shifting into undesired states [4]. Biodiversity is essential for the Earth's functioning and our basic survival and well-being, which is not entirely correlated to consumption or monetary income [5], but relates to nature, social relationships, knowledge, and politics [6]. The societal implications of biodiversity loss were pointed out in the millennium ecosystem assessment, noting a 60% loss of ecosystem services in the last four decades of the 20th century alone [7, 8]. Globally, it is the poor who are facing the earliest and most severe impacts of this loss, but ultimately all societies and communities will suffer [9].

Sustainable development, defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs, by extending to all the opportunity to fulfill their aspirations for a better life [10], is the ultimate strategy to reverse this drift to human self-extinction (see also [11, 12]). The research field and concept of biodiversity, natural capital, and ecosystem services (ES) are indeed rooted in sustainability thinking (e.g., [13, 14, 15, 16, 17]). The explicit link between sustainability and ES assessments [18] stresses the importance of all three values of ES: ecological sustainability, social fairness, and economic efficiency. Conclusively, the final goal of ES valuation is to achieve a more sustainable resource use, contributing to the well-being of every individual, now and in the future [8] by providing an equitable, adequate, and reliable flow of essential ecosystem services to meet the needs of a burgeoning world population [19].

Until now, there has been a reluctance to fully embrace the message that by ignoring the dependence on our natural capital we are literally living at the expense of the poor and the future generations [20]. Still, the ecosystem service (ES) concept could be an effective lever to contribute to sustainable development with more than just lip service (Chapter10). The ES concept has been picked up widely, percolated in many policy documents, and is being implemented in a variety of contexts. As the time left to effectively tackle sustainability challenges is running out, urgent refocusing of ES research and more importantly practice on its strong sustainability roots is essential. This conclusion directly arises from the methodological and conceptual challenges for ecosystem service valuations in this volume, echoes in many reflections from practice, and mirrors current scientific opinions on the topic (e.g., [19, 21, 22, 23] and others mentioned in this editorial).

There are no silver bullet solutions to be found in this volume. This is not surprising, as literature shows that "one size fits all" solutions are to be avoided [20] and complex problems will require diverse solutions [24]. Reading this volume will probably raise more questions, as awareness grows on the multitude of informed choices to be made on ever morecomplex matters. Once one is aware of this complexity, there seems to be no way back to easy solutions comfortably embedded within a single research or policy field. However, some key issues repeatedly and consistently surface throughout the variety of contributions, and they provide the focus and common ground for continued but innovative ecosystem service research and practice. Notwithstanding the diversity of insights found throughout this book, the key issues represent shared concerns among scientists, policy makers, and practitioners, and provide a frame of reference for practical implementation.

1. LIMITS

Limits (with related terms such as boundaries, resilience, carrying capacity, tipping points, and thresholds) refer to the ecological sustainability value of

Costanza and Folke [18]: the fact that ecosystem services, however efficiently used, depend on a limited amount of natural capital. Biophysical renewal of this capital occurs at a certain rate and involves complex and incompletely known ecological processes. Depletion by excessive use rates or negative effects on the supporting ecosystem will decrease the well-being of (future) beneficiaries. This relates to the concepts of the carrying capacity of nature [25], the planetary boundaries [1], and resilience [19]. Although this notion is intuitively evident and widely recognized throughout literature as a main challenge for implementation of the ES concept, it is hardly implemented in current practice. Many policy-related research papers and documents—beyond their introductions—almost exclusively emphasize efficiency (e.g., [26]) without questioning the indispensable (re)definition of the growth paradigm ([27]; Chapter 8) to stay within our ecological limits by defining boundaries to resource use.

Also in this volume, it is recognized that cost-benefit approaches can place underlying ecological assets at risk by overconcentration on changes in benefits (Chapter 2). Inclusion of underlying biodiversity for current and future service supply is still one of the main challenges in valuation (Chapter 11). This is why biodiversity management strategies should focus on maintaining and improving resilient systems, which increase long-term delivery of services (Chapter 3). Indicators could help in pointing out critical thresholds but rarely do so (Chapter 4; see also 20), while many economic indicators even implicitly but wrongly threaten the benefits of future generations through discounting rates (Chapters 6, 20). It stands out that ecological sustainability should be prominently included in the inclusive valuation framework (Chapter 1), despite the uncertainties and complexities involved (Chapters 14, 15). Deriving benefits from ecosystem services while respecting ecological boundaries requires shifts in current practices and often *painful choices* [10], as is illustrated for instance concerning agriculture (Chapter 22).

2. FAIRNESS

Although the first theme implicitly refers to intergenerational fairness and equity that can only be achieved by ensuring stable delivery of ES through time, sustainable equitable sharing also implies equity across regions and actors. Referred to variously as equity, solidarity, rights, common goods, benefit distribution, multiple values, option value, future values, and intangible values, it links to the social sustainability value of Costanza and Folke [18]. In the United Nations Rio declaration on environment and development from 1992 it is also known as the sustainable development principle, which states that *nations have the sovereign right to exploit their own resources, but without causing environmental damage beyond their borders*. Failure to respect this principle will (and already did) create environmental debts of some regions toward others (see, e.g., Chapter 1). International and global fairness are, however, often overlooked in the place-based ecosystem assessments, while global trade, for

example, impacts highly on biodiversity and ES (Chapter 17). Sustainability has to *ensure that the poor get their fair share of the resources, and it requires that those who are more affluent adopt their lifestyles* [10]. Although a trade-off between global equity (fairness) and environmental goals (limits) is often presumed, recent analysis points out that significant synergies can be developed by adopting a unified approach [28], and ecosystem services approaches could be useful to address poverty alleviation [29]. Indeed, contributions from both science and practice point out that fairness and distribution issues among (local and global) individuals or groups of actors need to be better considered. Fairness should be at the core of valuation of ES. Moreover, monetary valuation cannot value everything (Chapters 1, 2), and when going beyond awareness raising, monetary valuation tools (e.g., Chapter19) should be used to complement and not substitute other legitimate reasoning to biodiversity conservation. This neatly responds to further critiques on strictly monetary approaches (Chapters 6, 9, 11) and the call for application of combined valuation approaches [20] within an integrated and multidimensional approach capturing the broader value of biodiversity and ecosystems (Chapter 3) and demonstrated in the human health chapter Chapter 16). The required inclusion of beneficiaries at the wider geographical scale (Chapter 11) is elaborated in the context of rural development (Chapter 21) and global trade (Chapter 17).

Therefore, a three-pillar valuation framework is proposed (Chapter 1), valuing for efficiency but in a democratic way, taking into account social fairness (i.e., distribution effects) and system boundaries. To help this process along, indicators capturing well-being and economic wealth in a more holistic way are needed (Chapter 4) and are to be used in deliberative methods (Chapter 15), which cope with stakeholder involvement and power aspects in ecosystem governance (Chapter 5; see also 20), to empowerment of regional policy makers and local stakeholders (Chapters 30, 41). Most practitioners point out that ethics and the need for a moral framework that integrates them are needed to implement ES (e.g., Chapters 31, 33, 35, 38).

3. COMPLEXITY

Ecosystem services research aims to analyze the relation between the natural environment and human society: the socioecological system. Socioecological systems are highly complex and poorly understood, as pointed out extensively in this book by referring to uncertainty, data gaps, risks, complexity, and the like. Generally, valuation applications disregard the uncertainty factor, and this is a real problem [20]. The gaps in our understanding of relating services to production of human well-being are serious problems for robust valuation of ecosystem services (Chapters 1, 4). From a critical complexity perspective, full and objective knowledge of complex issues is unattainable. Complex issues will always be characterized by uncertainties, unknowns, and ambiguity. Dealing with complex issues therefore requires choices, which by definition are normative, and

by this we enter the domain of social debate (Chapter 13). Even the complexity of these issues is itself subject to negotiation (Chapter 15): The complexity to be taken into account and the approach for dealing with that complexity are part of context-specific negotiation among actors. Agreed-upon assumptions concerning the prevailing economic model, scaling aspects, and intangible values invoke decision risks to society and call for sound uncertainty quantification and honest communication (Chapter 14). Valuations should include a risk and uncertainty analysis to acknowledge the limitations of current knowledge (Chapter 11). Rather than focusing exclusively on minimizing uncertainties and ignoring complexity, herewith paralyzing or slowing down practice and discarding crucial issues, researchers and practitioners should adopt a more tolerant and pragmatic attitude toward complexity (Chapters 14, 15).

Concrete solutions to tackle complexity are sought in organizational aspects of ecosystem service assessment practices, such as analytical-deliberative approaches (Chapter 15). For instance, applying a consensus classification could decrease incompatibilities and promote comparability among assessments (Chapter 18). More importantly, inter- and transdisciplinarity are considered the only approaches to take into account nonuse values (Chapter 2), to perform a relative weighting of modeled supplied services in a bundle (Chapter 20), to realize an integrated valuation (Chapter 11), to reduce uncertainty and work inclusively (Chapter 1), to build understanding of socioeconomic systems (Chapter 11), to develop indicators (Chapter 4), and to increase policy uptake (Chapter 12). Conclusively, ecosystem services research and governance of complex socioecological systems have to incorporate the diversity of relevant stakeholders and issues (Chapter 5). This challenge is partly interdisciplinary: natural and social sciences have to be integrated; and partly transdisciplinary: apart from scientific knowledge, nonscientific knowledge, such as practical experience, is also relevant (see also [30, 31]). As research choices are partly normative, it is legitimate and reasonable to include stakeholders in the methodological decision-making process. Normative diversity and ambiguity can be reduced or at least can be made transparent by acknowledging moral and societal values and incorporating them in decision making (Chapter 1). This strategy can take into account complexity and organize critical mass (see also 19), although, simultaneously, pragmatic simplification and structuring of complexity is needed (Chapter 15).

4. REALITY CHECK

Ecosystem services, like biodiversity, is a mission-oriented concept (Chapter 3): Sustainable management of natural resources to increase human well-being has always been the final aim. But how does one check whether ES lives up to this expectation? Where best to judge the proof of concept? Throughout the book, contributors refer to "practice" to locate the concept's usefulness (Chapter 23). However, different, but partly overlapping, types of practices can be distinguished,

such as scientific practice, discursive practice, policy practice, and on-the-ground practice. *Scientific* practices focus on methodological issues such as valuation approaches, evaluation and learning, performance indicators, and best practice methods. *Discursive* practices focus on meanings, for example, in public debate or in policy texts. *Policy* practices focus on governance and policy instruments. *On-the-ground* practices relate to concrete actions or developments, for example, in international trade, agriculture, biodiversity and nature management, land-use management, public health, financial business, and nature education.

With regard to practice in terms of knowledge production and policy making, the concept of ecosystem services risks remaining a paper concept without real-life implications. With regard to knowledge production, involvement of stakeholders should be aimed at ensuring the practicality of projects, as end users will have to use the results in their day-to-day practices (Chapter 27). This is essential to address obstacles for implementing ecosystem service concepts in practice. The other way around, theoretical reflections are crucial for real-life practice: Discussions in the book show how choices often remain implicit or not thoroughly discussed, substantially impacting the outcomes. Even though some practical tools already exist, practitioners feel that more research is needed on the concepts' definition, scope, tools, conditions of use, effects, and practice at political levels, in order to help adapt human activity, stop ecosystem and biodiversity degradation, and improve its status as a result (Chapter 31) A more integrated approach to environmental management seems to offer possibilities/avenues to free mainstream practice from blindly simplifying the difficulties at stake (Chapter 21).

Engaging in practice, however, presents challenges, as the position of both scientists (as objective technician) and decision makers (as taking an informed decision "for the benefit of all") is heavily challenged when implementing ES in practice (Chapter 14). Nevertheless, this seems the only proposed way to take the concept of ecosystem services where it belongs: real-life, sustainable practice.

A PRACTICAL GUIDE TO THE OUTER COMFORT ZONE

There is no clear roadmap for the challenge outlined here. Professionals have to navigate with only a few general common aims as a beacon. Rather than listing detailed methodological guidelines, which abound in the recent literature, we summarized the core ideas in a short checklist. Four points should be kept in mind and transparently addressed if ES research and practice are to contribute to a truly sustainable resource management.

The list presented here is not a guarantee of success. The four points surface as essential concerns throughout the contributions to this book, and failing to address even one of them could diminish the effectiveness of any ES approach.

The above-mentioned themes are strongly linked, as are the points in the checklist: Limits relate to fairness, as they consider intergenerational fairness by

acknowledging risk of future decreases in service supplies; fairness considers the current distribution of benefits, as well as the transparency and legitimacy of complex research and decision-making processes; complexity again abounds in all three other themes, as does the need for critical reality checks. This said, different contexts of practice will pose specific challenges: For instance, pure awareness raising is a leap forward in a nonaware community, but in other contexts or later stages, focusing on it without on-the-ground realizations can be discarded as green washing. Thus, transparency on which points to prioritize throughout the process is required.

Point 1: Reduce Resource Use

Planetary boundaries are being crossed, risking a shift to atmospheric and climatologic conditions lethal for the human species. The resilience of many local systems is eroded, their thresholds are crossed, and future service supplies are jeopardized. Focusing research on the implementation of limits at different scales is essential. Because very few methods are available, the development of innovative multiple evidence-based approaches, expert judgments, and precautionary principles is needed. Aiming practice at reducing aggregated resource use is key, inasmuch as resource use efficiency, which is the prevailing focus, will not be sufficient.

Point 2: Redistribute Benefits Fairly

Sustainable development in a finite resource context inevitably requires redistribution to reduce poverty: We can no longer all have more. Focusing research on the assessment of values and benefits in a broad perspective is crucial, by representing people and groups that are not represented at all or hardly so: notably, indigenous people, third and fourth world populations, and so on. In practice, benefits have to shift to those global citizens who have the smallest share of benefits, at the cost of those who have an unequally large one.

Point 3: Accept and Acknowledge Complexity

Time has run out. We will have to act based on a limited understanding in a context too complex to completely grasp. Reducing uncertainty can no longer impede action. Acknowledging complexity and associated risks is essential to legitimize decisions, and this invokes transparent, multiple evidence-based approaches, including the values and beliefs of indigenous groups and multiple stakeholders. This means revising traditional science-policy-society interactions.

Point 4: Evaluate and Adapt Based on Reality Checks

Awareness does not necessarily produce behavioral change, neither personally nor institutionally. Planning and demonstration do not always result in