biodiversa
The ERA-NET promoting European research on biodiversity

BELMONT FORUM

HANDBOOK ON THE USE OF BIODIVERSITY SCENARIOS

in support of decision-making

To cite this report

Goudeseune, L., Solerød, M., Aleksandrova, M., Asanica, A., Eggermont, H., Jacques, C., Le Roux, X., Lemaitre, F., Popa, A., Ungvári J. (2020). Handbook on the use of biodiversity scenarios. BiodivERsA-Belmont Forum report. 36 pp.

DOI: 10.5281/zenodo.3979340

Main contact for this report

Lise Goudeseune: l.goudeseune@biodiversity.be (BelSPO/Belgian Biodiversity Platform)

Photography credits

Figure 1. Arend van Dam. "Future". Invoice number 1608410, 8/20/2020

Figure 5. Hoger Harvey. "Scenarios can help assessing plausible futures for socio-ecosystems and biodiversity, accounting for multiple pressures and their complex". Permission for free publication from 8/04/2020

Other pictures: pixabay, Pexels

biodiversa

The ERA-NET promoting European research on biodiversity

Created in 2005, and transformed into a long term partnership in June 2018, BiodivERsA is a network of 39 agencies and ministries from 25 countries programming and funding pan-European research on biodiversity, ecosystem services and Nature-based Solutions on a competitive basis.

Over 2008-2020, BiodivERsA launched 10 calls; it funded 125 transnational research projects selected for their scientific excellence, societal/policy relevance and quality of stakeholder engagement for a total amount of over 235 million euro (including ca. 150 million euro of money directly raised by BiodivERsA partners and the European Commission).

To further strengthen the European Research Area on biodiversity and ecosystem services, BiodivERsA has further developed a great diversity of activities ranging from research mapping and programming, to stakeholder engagement, dissemination of projects' outputs and knowledge brokerage.

For more information: www.biodiversa.org

BELMONT FORUM

Established in 2009, the Belmont Forum is a partnership of funding organizations, international science councils, and regional consortia committed to the advancement of transdisciplinary science. Forum operations are guided by the Belmont Challenge, a vision document that encourages: International transdisciplinary research providing knowledge for understanding, mitigating and adapting to global environmental change.

Forum members and partner organizations work collaboratively to meet this Challenge by issuing international calls for proposals, committing to best practices for open data access, and providing transdisciplinary training. Each proposal submitted to a call theme must consist of a project co-developed by natural scientists, social scientists, and stakeholders that hail from at least three countries. The Belmont Forum is also working to enhance the broader capacity to conduct transnational environmental change research through its e-Infrastructure and Data Management initiative.

Since its establishment, the Forum successfully led 18 calls for proposals, mobilizing over 150 million euros, supporting 134 projects and more than 2200 scientists and stakeholders, representing 70 countries on 6 continents.

For more information: www.belmontforum.org

BiodivScen

The Belmont Forum and BiodivERsA have joined forces to implement the joint programme "BiodivScen", for supporting international research efforts in the development of scenarios of biodiversity and ecosystem services. This programme runs from October 2017 to June 2023.

BiodivScen consists of a joint call for international research projects and a set of other activities addressed to researchers, non-academic stakeholders and research programmers of this domain. These activities include networking and capacity building events for researchers, as well as dedicated support and events for the engagement of stakeholders and for the uptake of research results in non-academic realms. Building on the contributions from the BiodivScen-funded projects, scientific foresight work will also be performed, aiming to identify new research frontiers, gaps and priorities related to the development of biodiversity and ecosystem services scenarios.

The European Commission participation in BiodivScen

This programme is co-funded by the European Commission under the Horizon 2020 programme as an ERA-NET COFUND, which is a funding tool aiming at strengthening the coordination of national and regional research programmes.

FOREWORD

Scenarios have been recognised as a powerful tool for exploring plausible future dynamics and uncertainty in complex systems. Yet, produced scenarios are not used enough, and there is a lack of existing guidance on how to ensure that scenarios are relevant to stakeholders and ultimately properly used in decision-making contexts.

This handbook intends to fill this gap for biodiversity scenarios in particular.

It was produced in the context of a *BiodivERsA-Belmont Forum* joint Action (BiodivScen) to support international research on scenarios of biodiversity and ecosystem services. This included funding multidisciplinary research projects that integrate the scenarios approach into their research, and other activities ranging from capacity building to outreach.

One of the objectives of this Action is to promote the science/society – science/policy interfacing within the funded projects and to create capacity for the use of their scenarios as decision-making tools at different scales.

The handbook does not intend to develop all aspects related to scenarios in detail. Rather, it provides an entry point to the main concepts and points out to essential

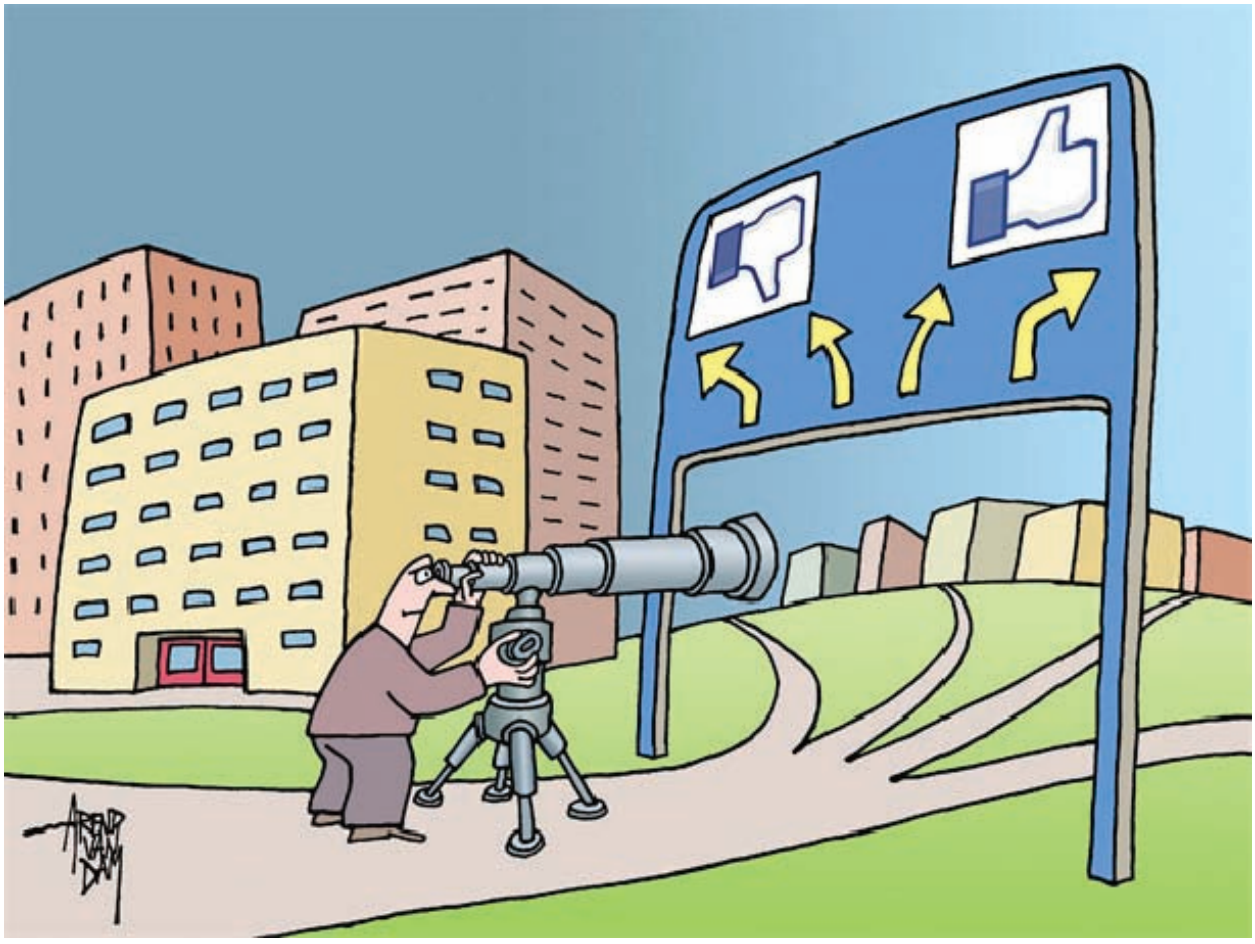


Figure 1. Scenarios are tools for exploring plausible future dynamics and uncertainty in complex systems.
© Arend van Dam

resources that are available to the community so as to increase the development and use of biodiversity scenarios.

It aims at highlighting approaches that make scenarios comprehensible, relevant and useful to stakeholders by the means of efficient language and targeted communication measures.

Its main target audience are producers and co-producers of biodiversity scenarios (mostly scientists), as well as potential users of scenarios (policy-makers, practitioners, businesses) who have a basic scientific knowledge about scenarios.

The first part of the handbook outlines the foundations or theoretical framework that is needed to understand scenarios; the second part highlights some BiodivScen and BiodivERsA-funded projects that have engaged stakeholders with their scenario work; the third and final part contains key resources on the development and use of scenarios, including the list of references cited in this handbook. In addition, a full list of resources and the complete bibliography that was used to produce this handbook is available on the *BiodivERsA website*.

Several publications of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (*IPBES*) have been extremely instrumental in this endeavour, in particular the IPBES Methodological Assessment on Scenarios and Models and its summary for Policy Makers. They are thus an important source of information for this handbook and a key resource on the use of biodiversity scenarios for policy-making and decision-making. Another important source of information are the interviews conducted with scientists funded through BiodivScen or several BiodivERsA calls, and with some stakeholders actively involved in these projects.

ACKNOWLEDGEMENTS

This Handbook draws on a variety of helpful sources of information on biodiversity and scenarios. The authors acknowledge the valuable help and feedbacks of academic and non-academic respondents to the online consultation organized from 27 April to 18 June 2020 and of Members of the IPBES Task Force on Scenarios and Models.

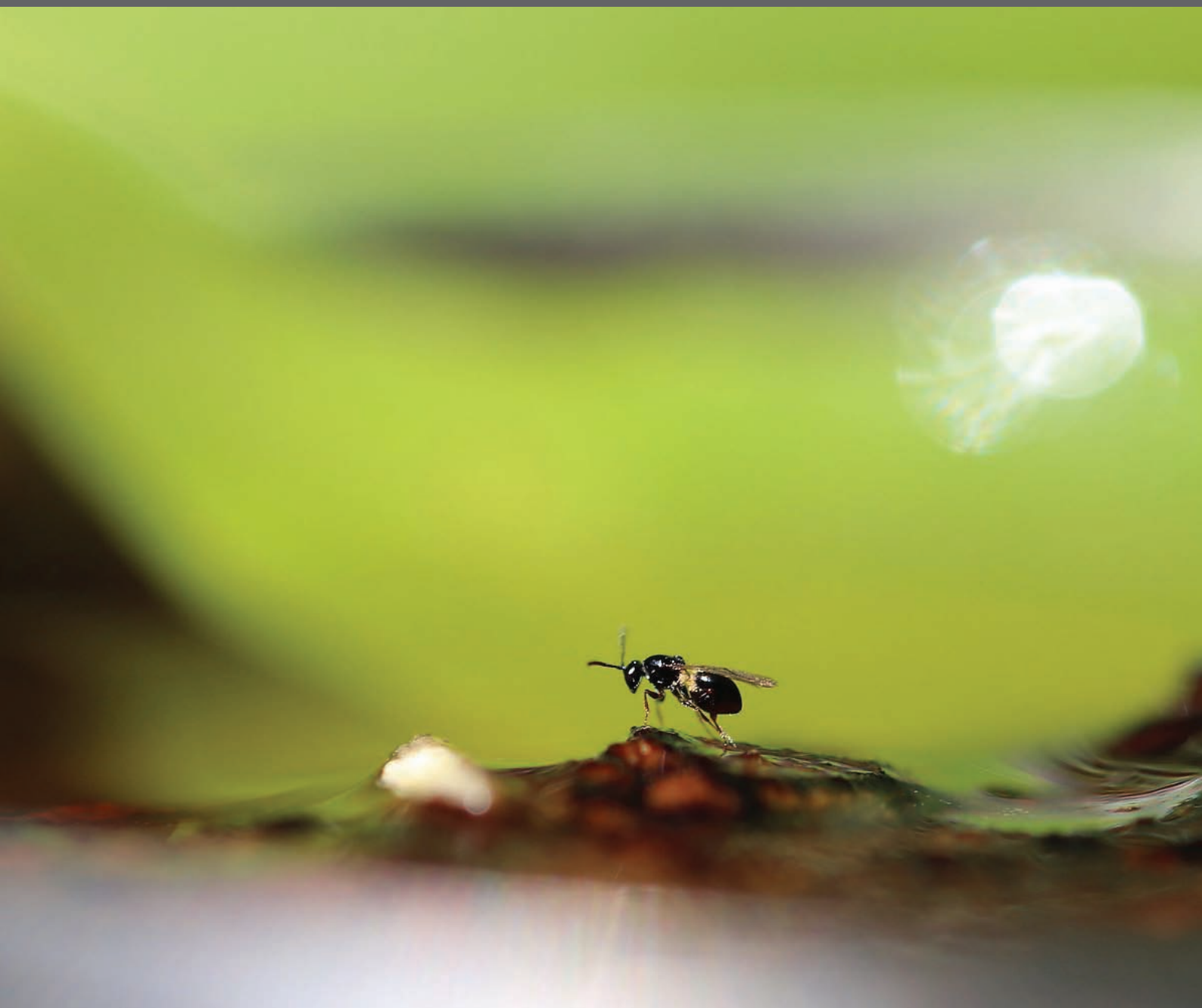
The authors are also particularly grateful to the project investigators and their stakeholders who took part in interviews for their time and helpful contributions in the development of the case studies presented in this Handbook.

TABLE OF CONTENTS

HANDBOOK ON THE USE OF BIODIVERSITY SCENARIOS

in support of decision-making

Part 1. The Foundations



I. DEFINITIONS & SCOPE: WHAT IS A (BIODIVERSITY) SCENARIO?

A. WHAT ARE SCENARIOS?

Scenarios are plausible descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces and relationships (see Fig. 2) (Biosphere Futures, 2019).

According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (*IPBES*), biodiversity scenarios are representations of possible futures for one or more components of a system, for example of drivers of change in biodiversity and ecosystem services, including alternative policy or management options (IPBES, 2016a; CBD, 2017; IPBES, 2018).

Scenarios are not predictions; they do not represent a consensus on what the future holds. Rather they are tools that can inform decisions, forming a basis for strategic conversation by providing common language & concepts for thinking about events (Shell, 2008).

Unlike forecasting, the purpose of scenarios is thus not to predict the future or to assign a likelihood to future events, but to explore and anticipate a range of different possible trajectories to make well-considered decisions for the future today (Biosphere Futures, 2019).

Projections and scenarios are different but close concepts: a projection can be regarded as any description of the future and the pathway leading to it (IPCC, 2013); while a scenario is based on a coherent and internally consistent set of assumptions about driving forces and key relationships (Climate4impact, 2012).

Scenarios are not meant to describe a single possible pathway: they envision multiple futures and acknowledge that the future reality might integrate elements

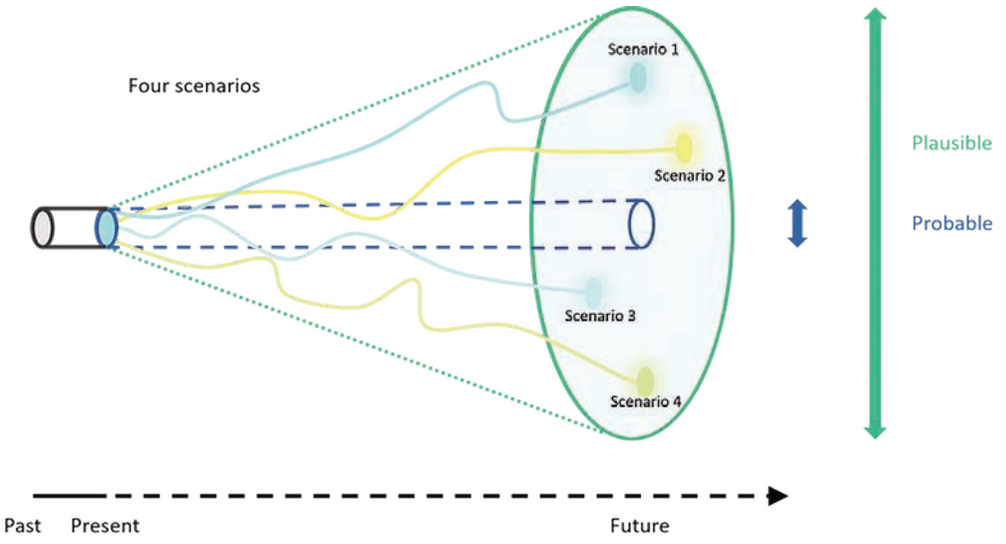


Figure 2. Schematic representation of how scenarios explore plausible future trajectories (Source: Biosphere Futures, 2019)

of different scenarios, depending on the decisions that will be taken and how social, political, and environmental events will unfold (D. Couvet, online consultation, 4 May 2020[1]).

Scenarios differ from models, which are qualitative or quantitative descriptions of key components of a system and of relationships between indirect and direct drivers[2]. Models aim to relate every entity involved, albeit sometimes only qualitatively. Models have to be coherent but might not be comprehensive. Scenarios, on the contrary, aim to be comprehensive and to address all the relevant questions, which can be at the expense of coherence, lack of plausible relationship between different elements of a single scenario (D. Couvet, online consultation, 4 May 2020[1]). Scenarios and models thus play complementary roles (IPBES, 2016a).

B. DIFFERENT TYPES OF SCENARIOS

The IPBES recognizes four different types of scenarios, each playing an important role in relation to the major phases of decision-making (see Fig. 3 and Table 1) (IPBES 2016a; IPBES, 2018).

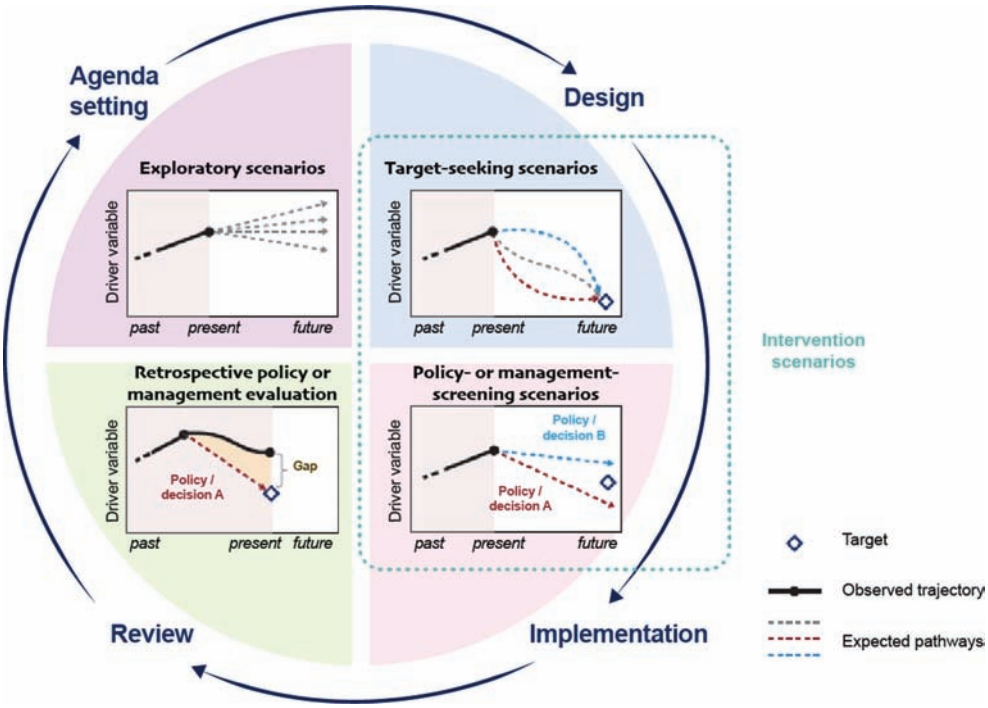


Figure 3. Main types of scenarios that can be developed, according to the objective of scenario builders and users (Modified after: IPBES, 2016a). *In **exploratory scenarios**, the dashed lines represent different plausible futures, often based on storylines. In **target-seeking scenarios**, the rhombus represents an agreed-upon future target and the coloured dashed lines indicate scenarios that provide alternative pathways for reaching this target. In **policy/management-screening scenarios**, the dashed lines represent various policy options under consideration. In **retrospective policy evaluation**, the observed trajectory of a policy implemented in the past (black line) is compared to scenarios that would have achieved the intended target (dashed line).*

[1] Pr. Denis Couvet, French Muséum National d'Histoire Naturelle, Professor or Ecology and Conservation Science.
[2] Drivers of change are all the factors that, directly or indirectly, cause changes in biodiversity, anthropogenic assets, nature's contributions to people and a good quality of life (IPBES, 2018).

Table 1. Types of scenarios in relation to major phases of decision-making (after IPBES, 2016a).

	What are they for?	What exactly are they?
Exploratory scenarios	**• For awareness raising and agenda-setting** They answer questions such as: *If we chose certain options (consumption behaviour, urbanization rates...) generating specific trajectories of drivers, what would be the effects on biodiversity?*	They examine a range of plausible futures, based on potential trajectories of either direct (e.g. climate change, pollution, land-use change,...) or indirect (e.g. socio-economic or demographic factors, technological developments, culture and behaviour,...) drivers of biodiversity. They allow for awareness-raising, problem identification, and agenda-setting and to stimulate creative thinking. They provide an important means of dealing with high levels of unpredictability, and therefore uncertainty, inherently associated with the future trajectory of many drivers. Stakeholder analysis should be considered here as it allows for the identification of stakeholders who will be affected by the decisions, and who have the capacity to be influential in the management or decision-making process (e.g. Raum, 2018).
Target-seeking scenarios[1] (intervention scenarios)	**• For designing interventions towards specific targets** They answer questions such as: *If a certain target is to be achieved (e.g. keep a certain extent of natural areas, to reduce biodiversity loss, ...), what are the possible pathways to reach this goal?*	This type of scenarios uses "target-seeking" analysis and contributes to policy design. Based on an agreed-upon future target, they focus on how a desired future can be achieved. They are valuable tools for examining the viability and effectiveness of alternative pathways to a desired outcome. They start with the definition of a clear objective or a set of objectives that can either be specified in terms of achievable targets or as an objective function to be optimised. Nature-Based solutions should be considered because they are interventions that can help reduce biodiversity loss (i.e. Faivre et al., 2017).
Policy- or management-screening scenarios (intervention scenarios)	**• For implementation of interventions** They answer questions such as: *What would have happened if other policy/management options were considered?*	They consider various policy or management options and are used to forecast the effects of alternative policy or management interventions on biodiversity outcomes: in policy-screening scenarios, a policy or management is applied and an assessment of how the policy/management modifies the future is carried out.
Retro-spective intervention evaluation scenarios	**• For evaluating interventions that have been implemented** They answer questions such as: *Have the policy options (e.g. locations of Marine Protected Areas and level of protection chosen) achieved the anticipated outcomes and goals (e.g. fish stocks and marine biodiversity)?*	The trajectory of a policy or management implemented in the past is compared to scenarios that would have achieved the intended target. The outcomes of previously adopted policies or management practices can be compared to hypothetical or alternative policies or management practices.

[1] Both target-seeking scenarios, and policy/management-screening scenarios are part of the group of "intervention scenarios".

	Any examples?
Exploratory scenarios	For instance, in Wisconsin, USA, three scenarios were developed on the potential futures of the region's freshwater ecosystem services (ES). The ES impacts of each scenario helped to identify the risks and opportunities the future might bring (McKenzie et al, 2012: 10). These are the types of scenarios developed by the IPCC[2]. They are the easiest to comprehend and to which people are the most familiar with. See also: the projects GreenFutureForest, CoForTips, and SECBIVIT (in **Part 2**)
Target-seeking scenarios[1] (intervention scenarios)	For instance, the VOLANTE project designed three land-use scenarios or "visions" based on established targets of European policy and stakeholder's main aspirations regarding agriculture; forestry; nature conservation; green connections; and viability in rural areas. (VOLANTE, 2015). A recent study analysed the different long-term effects on economic and ecological forest values between four forest management scenarios. The scenarios were formulated by stakeholders representing the main views on management practices and were based on the objectives and strategies of these stakeholders (Eggers et al, 2020). See also: the projects GreenFutureForest and Envision (in **Part 2**)
Policy- or management-screening scenarios (intervention scenarios)	For instance, to demonstrate the effectiveness of a REDD[3] programme, two scenarios representing deforestation are developed: an intervention scenario (with REDD) versus a projection scenario (without REDD). By comparing them, it is possible to show the added benefits by quantifying the losses of forest carbon stocks that are likely to be prevented by the REDD programme (McKenzie et al, 2012: 52). See also: the SECBIVIT project (in **Part 2**)
Retro-spective intervention evaluation scenarios	For instance, a study from 2010 reviewed several approaches and "matching" techniques to evaluating the impact of protected areas on deforestation. It has demonstrated that many methods for impact evaluation will overestimate protection's effect and they have considerably lower impact estimates of forest protection than produced by other methods (Joppa & Pfaff, 2010). Two studies have compared the types of measures related to Marine Protected Areas that are most effective in reaching the objectives of conservation of marine and reef ecosystems, and ensuring sustainable fisheries (McClanahan et al, 2016; de Guzman, 2016).

[2] Intergovernmental Panel on Climate Change (IPCC), see the climate scenarios on GHG emission pathways 2000-2100 (Source: IPCC, 2014: Figure 11).

[3] REDD = UN programme for "Reducing Emissions from Deforestation and forest Degradation"

Some authors have identified **archetypes** of scenarios based on the observation that many scenarios have similar underlying storylines, assumptions, and trends in drivers of change; and they have demonstrated the usefulness of these categories in science-policy processes (Sitas et al, 2019; Harrison et al, 2019).

C. METHODS FOR DEVELOPING SCENARIOS

There is no typical procedure nor method to produce scenarios: it depends on several factors inherent to each scenario building exercise as well as on the general context in which they are produced. However, some general aspects can be presented.

There are two main, non-exclusive approaches for setting up scenarios (IPBES, 2016a):

- **Expert-based approaches**: using experts' opinion or knowledge to inform the various aspects of constructing scenarios and models of drivers.
- **Participatory methods**: which offer a more comprehensive reflection of prevailing conditions and other key inputs by involving stakeholders in their construction.

A common approach is to create a **set of scenarios**, because the future will probably be composed of several elements from different scenarios, and because having multiple options represents better the inherent uncertainties. Decisions should therefore be based on a range of plausible futures: there is never one answer and a single best scenario likely does not exist (Shell, 2008; Charron, 2014).

A publication by the WWF gives a comprehensive and detailed overview on the whole scenario building process: how to select the right scenarios, what are the different steps of the development, which questions should be considered in the planning phase, what are the timeframes, etc. (McKenzie et al, 2012).

The IPBES has a dedicated chapter on methods for developing scenarios and models for biodiversity and ecosystem services in their assessment report on scenarios and models (Pichs-Madruga et al, 2016).

Different methods can be combined to develop scenarios, based on the needs and objectives of the research, to develop a more holistic approach, to achieve better results, and to be more effective in a decision-making context (Van Berkel & Verburg, 2012; Star et al, 2016).

D. STAKEHOLDERS' INVOLVEMENT AND PARTICIPATORY APPROACHES

Scenarios for decision-making are most effective when the development process is participatory, flexible, and iterative (see Box 1). In iterative processes, stakeholders are involved to evaluate and provide feedback on different steps (see Fig. 3 and 4) and scenarios are revised and refined accordingly. This is why stakeholder engagement is particularly important in research projects that produce scenarios. Scenarios should also be updated based on evolving conditions, or emerging trends and issues (McKenzie et al, 2012).

Figure 4. Main steps of interactions between policy-makers or other stakeholders and scientists in the development of scenarios (Modified after: IPBES, 2016a).

Box 1: Collaborating on scenarios improves results and uptake

Participation of stakeholders in constructing scenarios can be a key feature for successful biodiversity scenarios planning and uptake.

- For instance, the IPBES recommends that successful applications of scenarios and models typically involve stakeholders at the initial phase of problem definition and feature frequent exchanges between scientists and stakeholders throughout the process through participatory approaches (IPBES, 2016a).
- As highlighted in the Land2Sea and SECBIVIT projects (see Part 2), stakeholder input increases the quality of scenarios by enhancing their relevance, legitimacy, and credibility. In particular it is essential to acknowledge the plurality of values and perspectives among people affected by the potential futures, as well as the existence of alternative knowledge systems (Berg et al, 2016; Biosphere Futures, 2019).

Engaging stakeholders can be achieved using a range of approaches. BiodivERsA has produced a handbook to help scientists in engaging stakeholders in their research, and a guide on policy relevance and engaging policy stakeholders in research projects (Durham et al, 2014; Lemaitre et al, 2018).

For instance, the **EIP-AGRI Focus Group on High Nature Value** (HNV) **farming** developed a scenario-like approach to understand the reasons for the rapid decline of HNV farming systems, with the aim to halt or reverse biodiversity loss caused by them. They proposed acceptable development pathways with stakeholders in an iterative process through various networks and projects (EIP-AGRI, 2016a).

Fig. 4 shows the major steps of interactions between policy-makers, stakeholders and scientists. Each step involves the interactive use of models and data (grey arrows) and requires information flow between models and data (green arrows). This is depicted as a cycle, but in many cases these steps will overlap and interact (IPBES, 2016a).

II. Applicability of scenarios

A. WHAT ARE SCENARIOS USED FOR?

Scenarios and models are useful tools to support decision-making and policy-making. They can evaluate not only whether targets are achievable but also how they can be achieved and with what level of certainty (Nicholson et al, 2018).

They are constructed to provide insight into drivers of change, reveal the implications of current trajectories, and illuminate options for action and policy; provide a forum for thinking creatively about and discussing uncertain futures and are used to:

- Coordinate and align scientific analysis by defining a set of future trajectories to use as inputs for scientific analyses of their consequences. For example, IPCC's Shared Socio-Economic Pathways (Riahi et al, 2016).
- Integrate multiple disparate data sources, knowledge systems and models, e.g. participatory modelling and indigenous and local knowledge (ILK).
- Produce or deepen knowledge and reveal uncertainty, i.e. the limits of that knowledge (unpredictability, gaps, dilemmas, points of uncertainty). For example, see Box 2.
- Stimulate discourses with shared understanding of a problem, exchange ideas and integrate different perspectives; and inform about topics and priorities. For example, see the SECBIVIT project (in Part 2).
- Analyse the consequences of distinct and different choices for management actions or policies. See Box 3.

(adapted from Kosow et al, 2008 and Biosphere Futures, 2019).

Box 2: Participatory Scenario Planning in the Doñana Protected Area

In 2009, a group of researchers developed socio-ecological scenarios (type: exploratory scenarios) for the Doñana protected area to assess potential pathways of the evolution of the area and its associated social-ecological system. The scenario planning process included local actors and stakeholders: they designated their preferred scenario which was used to identify management recommendations and strategic objectives to achieve (See: Palomo et al, 2011; Palomo, 2020).

Box 3: A Green Vision for Sumatra

A study from 2012 provided analyses of ecosystem services and wildlife habitat in support of the spatial planning process. Next to the baseline scenarios describing the state of ecosystem services in that region, they developed two scenarios (type: policy-screening scenarios) as well as maps which showed the differences in ecosystem services between the three scenarios. Results were used to identify priority actions for the government to implement (See: Bhagabati et al, 2012; Olwero, 2019).

B. LIMITS AND BARRIERS TO THE USE OF SCENARIOS

Despite the considerable potential of scenarios to support the formulation and implementation of targets for conservation and sustainable management of biodiversity, scenarios are still little used for this purpose (Waite et al, 2015; Willcock et al, 2016; Nicholson et al, 2018).

There are some inherent but also manageable limits in the support scenarios can offer for decision-making, e.g. (IPBES, 2016a):

- **Different policy and decision contexts** require different types of models and scenarios (no single approach);
- **Spatial and temporal scales** vary markedly between different policy and decision contexts; no single set of scenarios and models can address all scales (raising the methodological question of their interoperability);
- **Uncertainty**[1], which arises from a variety of sources: insufficient or erroneous data; lack of understanding of underlying processes; low predictability of the system, etc. Poorly evaluated and reported uncertainty may lead to serious misconceptions – both overly optimistic and overly

[1] Uncertainty concerns any situation in which the current state of knowledge is such that: the order or nature of things is unknown; and the consequences, extent, or magnitude of circumstances, conditions, or events is unpredictable, and credible probabilities to possible outcomes cannot be assigned (IPBES, 2018).

pessimistic – regarding the level of confidence with which results can be employed in assessment and decision-making activities.

Five key (yet manageable) barriers to the widespread and productive use of scenarios in policy-making and decision-making have been identified (IPBES, 2016a):

(i) **lack of understanding** by non-expert end-users about the benefits of and limits to the use of scenarios and models;

(ii) a **shortage of human and technical resources**, as well as data, in some regions;

(iii) **insufficient involvement of interactions** between scientists, policy-makers, and other stakeholders;

(iv) **lack of guidance in model choice**[1] and deficiencies in the transparency of development and documentation of scenarios and models;

(v) **inadequate characterization of uncertainties** derived from data constraints; problems in system understanding and representation; or low system predictability.

For further reading on common problems and challenges in participatory scenario planning as well as opportunities and ways to overcome them, see Oteros-Rozas et al (2015).

C. KEY FEATURES FOR MORE EFFECTIVE SCENARIOS

There is an abundance of existing scenarios, as well as relevant tools and methods. However, users of scenarios need to choose them carefully as they should be matched with the needs of their assessment or decision-support activity. They should also be applied with care, considering the uncertainties and unpredictability associated with model-based projections (IPBES, 2016a).

There is growing attention and research identifying the key features that make scenarios better suited to support decision-making (Nicholson et al, 2018; McKenzie et al, 2012):

- **Relevance & timeliness**: scenarios address salient issues of interest to stakeholders and decision-makers;
- **Participation**: stakeholders are involved in scenario development and analysis; there is good partnership and trust between the scientists, policy-makers and other stakeholder; commitment from all the parties;
- **Legitimacy**: scenarios include diverse, and even competing, perspectives and objectives;
- **Plausibility**: scenarios present coherent and conceivable stories;
- **Understandability**: scenarios and results are well communicated to the target audience;
- **Distinction**: scenarios are sufficiently dissimilar to show contrasting impacts and trade-offs;
- **Scientific credibility**: scenarios' storylines are scientifically robust, credible, and internally consistent;
- **Comprehensiveness**: all possible

[1] In this respect, the World Resource Institute (WRI) proposes a hands-on 5 steps method to decide which model to use in a particular decision-making context, as presented in Figure 10 of Bullock & Ding, 2018:10.

drivers are considered (direct and indirect);

- **Iteration**: scenarios are refined and revised based on stakeholders' inputs and emerging issues;
- **Surprise**: scenarios consider unexpected developments, challenge current views, and foster creative thinking.

Many studies emphasize the need for integrated approaches to link biodiversity, ecosystem services, and socio-economic dynamics. Citing Pereira et al (2018): "*Introducing complex feedbacks to biodiversity scenarios requires moving away from linear, non-interactive relationships between social and natural sciences, towards a more interactive, interdisciplinary association*" (an example of such an integrated approach is the JSSA in Japan, see Box 4).

For key characteristics of scenarios and criteria to classify scenarios which are helpful to better understand mechanisms and purposes, see: van Vuuren et al (2012).

Box 4: Scenarios for multiple ecosystem changes in Japan

The Japan Satoyama Satoumi Assessment (JSSA) was a study conducted on the interactions between humans and ecosystem in Japan. The authors adopted a qualitative approach to scenario development. They analysed the changes in satoyama-satoumi ecosystems (mosaic landscapes of different ecosystems) for over the last 50 years. From there, they identified four prospective scenarios for the year 2050 taking into account various drivers such as governmental and economic policy, climate change, technology, and socio-behavioural responses. The scenarios produced had implications for ecosystem services, human well-being, and biodiversity (UNU-IAS, 2010).

D. COMMUNICATING ABOUT THE UNCERTAINTY RELATED TO SCENARIOS

Communication is an important but difficult task when it comes to the proper uptake of scenarios. Open communication is particularly important because of the inherent uncertainty of scenarios.

Uncertainty is a complicated matter for stakeholders (e.g. unacceptance of uncertainty by some decision-makers) and also for the scientists themselves (e.g. lack of attention to uncertainty, or omission of elements with uncertain aspects). Therefore, **quantifying and communicating on uncertainty** is challenging. Interestingly, the scenarios approach has been considered a solution to communicate on uncertainty of predictions or models (Langsdale, 2008).

Several authors (e.g. Addison et al, 2013; Mahmoud et al, 2008; Hudson-Doyle et al, 2018) have outlined practical recommendations on how to deal with uncertainty in the context of scenarios, such as:

- use participatory approaches, continuously engage/involve stakeholders in the scenario development process;
- establish credibility and trust with the stakeholders;
- improve communication;
- make use of clear typologies and a language that is understandable to avoid misinterpretations;
- be transparent;
- do not merely suppress and reduce uncertainty, instead acknowledge and incorporate it.

For example, the IPBES uses a four-model box which relies on two metrics (level of agreement and quality and quantity of the evidence) for communicating the degree of confidence in key findings (IPBES, 2016b).

More generally, it is important that **capacities and limitations of scenarios and models are carefully evaluated and communicated** (IPBES, 2016a). The importance but also difficulty to communicate on scenarios are addressed by several scientists interviewed for this guide (see Part 2: Hands-on experiences of the projects CoForTips, SECBIVIT, Land2Sea, GreenFutureForest, and ENVISION).

III. Summary

Overall, biodiversity scenarios are powerful tools for stakeholder engagement. They support decision- and policy-making, in particular in the context of conservation and environmental management. The variety among the different types of scenarios explains why there is no single method to produce and make use of them. However, some key features are essential to develop useful scenarios. There are plenty of examples from the scientific and grey literature that can be a source of inspiration for the scientists or stakeholders interested in the topic.

The projects presented in Part 2, based on projects funded through either BiodivERsA or BiodivERsA-Belmont Forum calls, illustrate the diversity of use biodiversity scenarios offer to **practitioners** like **winegrowers**; **managers of national parks**; **NGOs, companies, landowners and farmers organisations**; **planners, state agencies and NGOs; and the Forest Stewardship Council,** in the projects SECBIVIT; ENVISION; GreenFutureForest; Land2Sea, and CoForTips, respectively; and **policy-makers** like the **European Commission and US national park managers**; **environmental and forestry agencies**; and **representatives of local, provincial and national governments** in the projects ENVISION; GreenFutureForest; and Land2Sea, respectively.

Part 2. Hands-on experiences

The process of building scenarios, involving stakeholders and putting scenarios to use, is not an easy exercise. Here are five examples describing it with some lessons learned. The material used for this part of the handbook was derived from the description of several research projects funded through BiodivScen or by BiodivERsA, along with interviews with scientists and stakeholders involved in these projects (statements derived from interviews in italics).

I. The CoForTips project

Type: exploratory scenarios.

From serious games to real-life changes

"By allowing decision-makers to directly play around with models and collectively build scenarios, they gain first-hand experience of socio-ecological transformations. This provides meaning to knowledge they might already have. Gaining exposure to the realities experienced by others can also inspire epiphanies, and dramatically alter their behaviour" explains Claude Garcia, ecologist at the CIRAD and coordinator of the BiodivERsA-funded CoForTips project.

OBJECTIVES

The future of the forests of the Congo Basin is constrained by two processes: climate change and the drivers of land use change - agriculture conversion, infrastructure development and logging. The CoForTips project and its twin project CoForSet identified ecological transitions between forest types allowing managers to better anticipate the ecological impacts of future interventions. It explored the synergies between landscape transformation and stakeholders' strategies. It helped decision-makers take a step back and look at the larger picture. CoForTips' starting point was the question of the resilience of the forests of the Congo Basin in the next decades. Burning topics were the development of mining, the sustainability of logging operations, the existence of poverty traps and power asymmetries, bushmeat hunting and poaching, and the conservation of High Conservation Value Forests including Intact Forest Landscapes in and out of the geographical scope of FSC certified concession[1].

[1] An Intact Forest Landscape (IFL) is defined as *"a territory within today's global extent of forest cover which contains forest and non-forest ecosystems minimally influenced by human economic activity, with an area of at least 500 km² (50,000 ha) and a minimal width of 10 km (measured as the diameter of a circle that is entirely inscribed within the boundaries of the territory)"* (*http://intactforests.org*)

A game of AgriForest in progress. The players have just completed the first session. Cocoa plantations are starting to produce, and the future looks bright. Tomorrow, they will have to face the unexpected: the arrival of migrants (Ampel, Cameroun, 2016). Credit: Claude Garcia

CoForTips, together with a parallel project CoForSet, worked to foster better management of the forests and landscapes of the Congo Basin. The objective was to i) understand and describe the socio-ecological dynamics of the regions' landscapes, ii) engage local and regional stakeholders in developing scenarios of how the landscapes could evolve, and iii) support dialogues and decision-making helping to shape tomorrow's forests and livelihoods in the region.

Stakeholder participation and scenario development

The boundaries of the project were guided by scoping exercises carried out with stakeholders in the very first phases of the project. CoForTips merged together the knowledge from the stakeholders' inputs, research results on ecological dynamics and descriptions of the norms and institutions prevalent in the study area, building models that describe the social and ecological system. These models were presented to the same stakeholders as strategy board games to be played collectively. Without specifying "victory conditions", the research team got them to freely elaborate scenarios based on their own views and decisions and were able to highlight the ways they had or could have influenced the outcome. This put decision-making and responsibility at the centre of the discussions.

Three days to change the state of play

FSC (Forest Stewardship Council) originally developed with stakeholders the concept of High Conservation Values (HCVs) forests, and how these can be protected. Intact Forest Landscapes in and adjacent to FSC forest concessions is a further field of work since 2014 based on a request of FSC membership. The definition of indicators and management norms for the management and the maintenance of Intact Forest Landscapes (IFLs) in certified forest concessions started at regional level through a regional working group including Environmental NGOs, representatives from civil society organisation, indigenous people and private sector. In the Congo Basin, the discussions were particularly difficult, due to the complexity of the topic and the apparent diverging positions between the parties involved. Informal contacts established a bridge between the policy process and the research project. In 2017, The FSC program for the Congo Basin learned about the CoForTips work on participative scenario building using serious games[1] and decided to give it a try.

FSC organized a three-day game session. They gathered 12 representatives from all parties that had already engaged in the earlier discussions. The first day was entirely devoted to learning and playing the game, allowing players to develop strategies over a period of 50 years, shaping the landscape based on their choices. The resulting scenario was then described with global ecological, social and economic indicators. The second day players analysed how their decisions and strategies had shaped the landscape, and they established connections between what they had experienced in the game and real case situations they were familiar with. They used the game to demonstrate to the others special cases that were of concern to those they represented. Visualizing alternative scenarios helps everybody un-

[1] Defined in Stone (2012) as "*games that move beyond entertainment alone to deliver engaging interactive media to support learning in its broadest sense*".

derstand each other better. The third day led to the development of a collective agreement for the management of IFLs in the FSC certified concessions of the Congo Basin.

- *In 3 days, the game opened new perspectives,* says Claude Garcia. *Players lived and experience the game; they understood and became actors in our models. We could show them how their individual decisions worked out in shared scenarios. If done properly, this is very powerful and when players have decision-making power, our experience is that their decisions change.*
- *Claude Garcia and his team (...) facilitated this workshop and allowed members (...) with a very heterogeneous education background to acquire, in two days, the same level of understanding regarding IFLs concept, and how each management decision impacts the landscape, its resilience and forest-dwelled peoples living in* explains Mathieu Auger-Schwartzenberg, Director of FSC's Congo Basin Programme at the time of CoForTips.
- *The playing role game and Claude Garcia facilitation really helped to understand the big picture and the regional impacts of our decisions,* added Mr. Georges Belmond Tchoumba, WWF Central African Programme Forests Coordinator.

KEY LESSONS

Having the right people, breaking the game taboo

- *Our experience is that the most difficult thing is to get the right people – people with decision-making power - around the playing board and convince hierarchies in organisations that this can be an actual game-changer. The military has no issues with using games to prepare for the worst, but it is taboo in natural resources management and policy,* notes Claude Garcia.

However, in 2019, the FSC Policies and Standards Committee considered the threshold[1] proposed by the Congo Basin regional working group to be outside the stipulations of the FSC International Generic Indicators (FSC-IGIs) under which the representatives of the regional stakeholders had the mandate to operate. As a result, the discussion on IFLs is still an ongoing process and FSC explores a way to finalize the process. It may very well be that there is a window of opportunity to expand and strengthen a new form of dialogue, learning from the success of the Brazzaville discussions. Based on the CoForTips/Set work and subsequent projects, Claude Garcia and colleagues are nailing down the recipe:

- *You need these five ingredients to have actual impact:* ***1) a model that works****, it has to be co-developed and realistic about socio-ecological and economic constraints and causality****;* ***2) good session facilitation****, that allows for independent decisions, while managing potential conflicts;* ***3) have the right people playing****, you need the decision-makers to play for the process to have an impact;* ***4) identify a convener****, people that have the credibility and courage to assemble people to construct a new solution no one knows what it looks like beforehand; and* ***5) time****, i.e. getting these people for three days in the same place.*

For more information: *the CoForTips project*

[1] Percentage for the IFL area to be strictly protected within the FSC concessions.

II. The GreenFutureForest project

Type: exploratory and target-seeking scenarios.

Looking into possible futures for forests

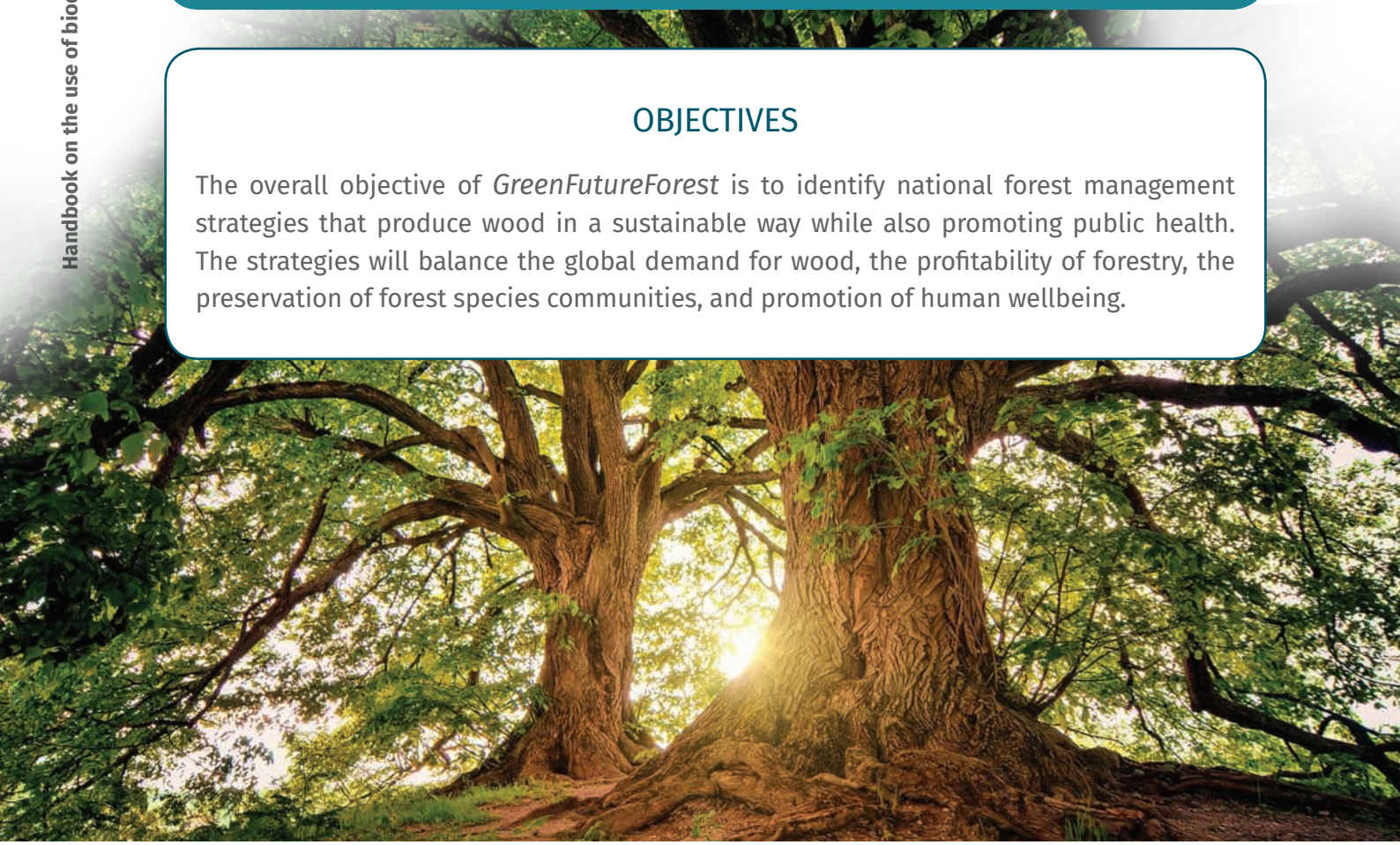
In the GreenFutureForest project, funded by BiodivERsA in its 2015-2016 call, the scenario researchers use empirical data from the past to offer glimpses into the future of forests.

"*What society often needs are qualified predictions, which is what we give them: we observe the present data on forests and rates of change, but extend them into the future*", says Tord Snäll, professor at the Swedish University of Agricultural Sciences and coordinator of the BiodivERsA funded project *GreenFutureForest.*

Building scenarios based on empirical data makes it possible for decision-makers to foresee the alternative futures, depending on the actions and choices made in the present, in this case the future of forests. Ecologists often base their description of biodiversity trends on empirical data. Is the population of a focal species going up, or is it going down?

OBJECTIVES

The overall objective of *GreenFutureForest* is to identify national forest management strategies that produce wood in a sustainable way while also promoting public health. The strategies will balance the global demand for wood, the profitability of forestry, the preservation of forest species communities, and promotion of human wellbeing.



Scenarios for biodiversity can impact on policy and industry, by making a discussion or a conflict less subjective, but more knowledge-based.

Stakeholder participation and scenario development

Knowledge needs and motivations for using scenarios for biodiversity in forests vary a lot, depending on the motives and occupation of the different stakeholders. The conservation NGOs can advocate that more old forests should be retained or that they should be cut at a higher age. But they have not seen the possible long-term consequences of what they advocate.

– *Using simulation software for forest management, we set up simulations to reflect what they advocate. Then we simulate what would be the long-term consequences of that*, Snäll tells.

This was particularly interesting for the organisations who were not familiar with these kinds of projection tools. In contrast, for example the Sveaskog company is experienced in using this software as a basis for their decision-making, for the forestry planning. That's what this system has been developed for. But no one has taken out the output from the forestry simulations and investigated "what if we combine them with models for biodiversity, how will the species respond to the scenarios?"

So, the project partners investigated the long-term consequences for conservation of species, building on these experiences, developing additional scenarios, elaborating the questions more, thus obtaining a firmer understanding of the role of the future green infrastructure of forest landscapes. The stakeholders provided new ideas and questions to be tested, according to their specific needs.

Lessons learned

Snäll and his team made sure to include stakeholders with different perspectives in the GreenFutureForest project. Hannah Östergård from the Swedish Environment Agency and Peter Bergman from Sweden's largest forest owner – Sveaskog. Together, they showcase how the same tool, in this case a program to design scenarios, leads to unalike learnings, results and experiences, depending on the aims and ambitions of them as stakeholders.

The forest owner's experience

Peter Bergman has the lead on the conservation work of Sweden's biggest forest owner – Sveaskog. As such, he has been involved by Tord Snäll and his team in several research projects over the years, the GreenFutureForest being the last in the line. Bergman has learned a lot from this collaboration, from the process as well as the outcome:

– *We have been working with scenarios earlier, but then more in an economic sense. For five years, we have been using the computer program HEUREKA to make prognoses on how much timber and pulp we can produce from our forest. But we had not included the factors concerning conservation issues and biodiversity before.*

Beside forests that are put aside, also different types of retention are essential for conservation. So, to preserve biodiversity, Bergman and his team also work on retention.

– *That's a long-term investment we must do. Taking a part in Snäll's scenario work made it possible for us to include conservation of biodiversity of species and to set quality goals for our retention areas into the program,* Bergman says.

Noticeably, Sveaskog's new leadership is currently working on a new strategy for the company.

– *The scenario project fits like a hand in glove for pointing out direction for our future conservation works. The result of our engagement in the scenario project will have a great impact at the highest strategic level at Sveaskog,* Bergman says.

The conservationist's experience

Senior Research Officer at the Swedish Environment Agency, Hannah Östergård, was engaged in the GreenFutureForest project, as being responsible for developing relevant Swedish Environment policies.

– *What I learned from the GreenFuture Forest experience is that we can use our scenario as an argument for conservation: it showed us that it does not have to cost that much, to have a more sustainable forestry, with less clear-cutting and more varied methods,* Östergård *says.*

At the time of the project, she worked at the analysis unit of the Agency, evaluating their environmental quality objectives.

– *The scenario gave us the opportunity to have a more quantitative view on our objectives, which was useful in our evaluation progress. Also, we introduced the results to our strategic forestry group at the Agency and shared it with the regional country administrative boards.*

Another important learning Östergård drew from being involved in the scenario building is the need for including social sciences in the process, to bridge the quantitative and the qualitative aspects of scenarios, thus making them more accessible and more easily accepted.

– *People often associate scenarios with the social science methods, developing qualitative scenarios, with narratives like "If we do that, this will happen, etc." We should try to translate our quantitative measures into a narrative, or at least include them in our narrative. In the GreenFutureForest case, that was to explain that we can decrease clear-cut forestry with 50 percent without losing more than ten percent of the financial gain. We currently work a lot with economists, but I believe also other branches of social sciences, such as behavioural science, philosophy and political science, could bring in valuable aspects to scenarios.*

Scenarios for biodiversity can impact on industry and policy, by making a discussion or a conflict less subjective, and more based on knowledge.

– *They show how different decisions may have different outcomes, and not always the outcomes that we foresee,* Östergård concludes.

For more information: *the GreenFutureForest project*

III. The ENVISION project

Type: target-seeking scenarios.

Policy for the inclusive management of protected areas

To make sure that their scenarios are timely and relevant for policy-makers, the ENVISION project, funded through the BiodivScen call, invited them to take active part in the project work.

"Assigning the International Union for Conservation of Nature (IUCN) the lead of one of our work packages opened space for communications with policy-makers at different levels", says ENVISION project coordinator, professor and expert on stakeholder involvement techniques, Christopher Raymond.

With first-hand knowledge about policy-makers' problems and needs, Raymond and his partners can adapt directly their scenarios to them.

OBJECTIVES

The ENVISION project aims at developing several communications and policy tools to identify, compare and balance the multiple visions for protected area management in any given area. The project also aims to facilitate societal reflection on future economic growth and landscape change, and to enhance the understanding of social and ecological consequences of different management choices.

View of the Alaska Range from Wonder Lake in Denali National Park. Credit: Dave Alexander/NPS
The ENVISION project brings together scenarios relevant at one scale, for them to become relevant at the European level.

The ENVISION project has a 6-step approach to a more inclusive management of protected areas, through comprehensive engagement of various stakeholders at different levels: 1) considering multiple visions for protected area management, 2) assessing the consequences of each vision, 3) social learning and collectively defining new visions, 4) assessing uncertainty and building resilience, 5) acknowledging power relations and rethinking governance and 6) informing biodiversity and protected area management policy. Their work revolves around case studies in national parks in Sweden, Spain, the Netherlands and Alaska, USA.

– *Each site has its own context-specific stakeholders called the "local site knowledge alliance" that are relevant to the problems we are trying to address there. Also, ENVISION has an inter-site knowledge alliance, with representatives from each site, plus representatives from the European Commission (EC) and from US national park organisations*, Raymond explains.

Stakeholder participation and scenario development

To involve different audiences at the different sites, the project partners use different tools and techniques, tailored to the respective stakeholder groups and the purpose for involving them. These tools and techniques are aligned with the 6-step approach to inclusive conservation.

– *In the Netherlands, they involve by a tool called STREAMLINE*[1]*, that uses cartoons to illustrate different visions for protected area management. People tend to be a lot more receptive to such tools that have a very strong visual component to them. Stakeholders can select cartoons which best reflect their visions for supporting biodiversity and human well-being in protected areas. These cartoons then form the base of a dialogue around biodiversity and well-being scenarios and their consequences for protected area management in ways that standard interview questions would not be able to do.*

ENVISION also strives to bring together and aggregate scenarios that are relevant at one scale, for them to become relevant at the European level. The project has been grappling with the cross-scale interactions from both biodiversity and human well-being perspectives.

Lessons learned

Science as provider of facts vs. solutions is one of the barriers in the dialogue between scenario scientists and the general public. People are used to receiving binary facts and solutions, either this or that.

– *As a community, we need to become more concerned by the range of possibilities. In the context of our work, it may not be that conservation is good and mining is bad. What is needed is to see the range of possible pathways and look at how these sectors interrelate. There is complexity in every pathway we take, and we urgently need to navigate that complexity. To be able to do that in an inclusive way, we need to communicate the uncertainties and the complexity associated with each pathway, not only to scientists in other disciplines, but also to different sectors of the communities*, Raymond concludes.

For more information: the ENVISION project

[1] For further information about STREAMLINE see: *https://www.streamline-research.com/services*

IV. The SECBIVIT project

Type: exploratory and policy-screening scenarios.

Scenario researchers uncovered needs for new policy

Rigid regulations make it difficult for winegrowers to tackle the effects of climate change.

Every year, most winegrowers manage the inter-row vegetation to regulate competition between herbaceous and grassy vegetation and the vines. They never know in advance how the weather conditions will be and when the best timing for management operations would be. In previous years, the variation has been greater than ever, likely due to climate change. Still, some national authorities impose fixed dates for certain agri-environmental schemes.

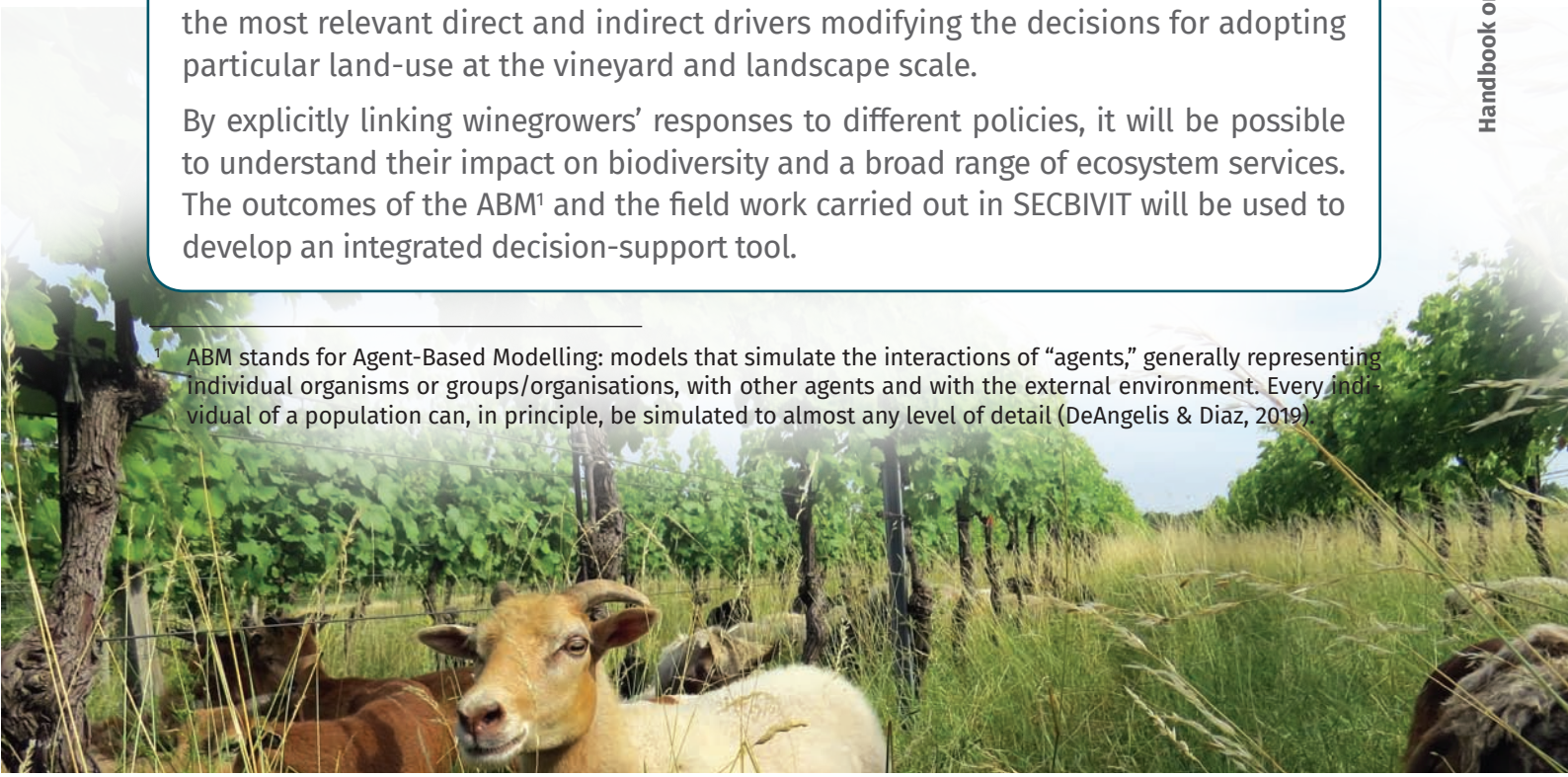
"*This is a problem, because nature itself cannot be predicted. Winegrowers must adapt their vineyard management in response to increasing weather extremes, elevated consumer and societal demands for sustainable production*", says Silvia Winter, researcher at the University of Natural Resources and Life Sciences in Vienna.

OBJECTIVES

The project SECBIVIT – *Scenarios for providing multiple ecosystem services and biodiversity in viticultural landscapes* – funded through BiodivScen aims to identify the most relevant direct and indirect drivers modifying the decisions for adopting particular land-use at the vineyard and landscape scale.

By explicitly linking winegrowers' responses to different policies, it will be possible to understand their impact on biodiversity and a broad range of ecosystem services. The outcomes of the ABM[1] and the field work carried out in SECBIVIT will be used to develop an integrated decision-support tool.

[1] ABM stands for Agent-Based Modelling: models that simulate the interactions of "agents," generally representing individual organisms or groups/organisations, with other agents and with the external environment. Every individual of a population can, in principle, be simulated to almost any level of detail (DeAngelis & Diaz, 2019).



Sheep and goat grazing is an alternative form of inter-row management in vineyards. Credit: Silvia Winter

Stakeholder participation and scenario development

To involve their most important stakeholders, the SECBIVIT project organises focus group meetings with winegrowers and establishes connections to the winegrower's own, local networks and meetings.

– *The relevance of scenarios was improved by the input we gathered here. Not all winegrowers necessarily think out of the box, but they have an opinion on what they think might or might not happen. And by taking that into account, we increase the relevance of our scenarios and their engagement in our project. We use these meeting-places as platforms to inform and engage and adapt scenarios*, says one of project partners, assistant professor Nina Schwarz from the University of Twente, in the Netherlands.

– *We invited them to focus group meetings, where they had the chance to meet each other and exchange in constellations they normally wouldn't have, interacting in a different way than they usually do in similar settings. They discussed questions they wouldn't have in their more normal planning, questions focussing on biodiversity and ecosystem services. Many of them were aware of this before, but now possibly more of them saw the connections between this and their wine production*, Winter tells.

For more information: the SECBIVIT project

Lessons learned

For the winegrowers, an important output of the SECBIVIT project was that the field experiments conducted in their vineyards provided them with information on different taxa, soil and grapevine parameters of their vineyards.

Scenarios cannot be presented as facts, but more as possible versions of the future. So how to communicate that to people outside the research community?

– *From previous projects I know it is complicated to communicate scenarios to stakeholders. We cannot claim they represent the truth, but at the same time we believe that there is added value for stakeholders if they make use of them in their decision-making,* Schwarz says.

The researchers suggest that to make the general public able to see the value of scenarios, how to deal with uncertainty should be taught in school.

– *We are striving for evidence-based policy-making, for policies to be based on empirical findings. But often we don't have a clear answer as to how to do that. In fact, we might never have a clear answer to that. Uncertainty is a complicated matter for winegrowers but also for scientists,* Winter concludes.

V. The Land2Sea project

Type: exploratory scenarios.

Engaging for better scenarios

Scientific evidence is not always enough to develop realistic scenarios. With input from people on the ground, researchers can improve their models.

Tasman Crowe from University College Dublin is the Principal Investigator of the project Land2Sea funded through BiodivScen. The project is still running as he and his project partner Daniel Hering share their thoughts and experiences on the added value of scenarios for the relevant users.

"*It's a little early in the project to say for sure, but we are hoping that our involvement of stakeholders in our work will make the results fit for purpose and put to use by those who need them in their decision-making*", says Daniel Hering, professor at the University of Duisburg-Essen.

OBJECTIVES

The project Land2Sea - *Integrated modelling of consequences of terrestrial activities and climate change for freshwater and coastal marine biodiversity and ecosystem services* - aims to develop an integrated framework for assessing the consequences of human activities for water quality and biodiversity. It will capture combined impacts of terrestrial inputs and climate change on freshwater and marine systems and incorporate physical, ecological and socio-cultural dimensions aligned with the Conceptual Framework of the IPBES. The framework will facilitate management to improve water quality and will support the objectives of European and international biodiversity policy to reverse species decline.

Bray, Ireland: a coastal community deriving benefits from terrestrial, freshwater and marine ecosystems.
Credit: Tasman Crowe

The project relates to the management of activities in and inputs to freshwater and coastal environments. The researchers established case studies in four coastal areas, involving relevant stakeholders in the process.

– *The first phase was an online questionnaire to collect data and knowledge from representatives of local, provincial and national governments, planners, state agencies and NGOs. We are using these data in developing our models. The second phase of the involvement will be to organise a series of workshops, in which we explore socio-cultural consequences of ecosystem changes face to face with a wider range of stakeholders and explain the models and discuss them with the stakeholders*, Crowe says.

The models at the heart of the research are Bayesian Belief Network models, which incorporate information from a wide range of sources to estimate probabilities of changes arising because of different levels of specified inputs and pressures.

Build trust and increase uptake

The project partners hope their scenarios will be more fit for purpose and that the uptake of their results will be greater because of the project engaging stakeholders with relevant hands-on knowledge and experience.

– *We expect much more realistic models. There are always certain questions in these complex models we mere scientists cannot answer. Some of our stakeholders know our various fields very well and bring in expertise that contribute to make our models much more realistic. Also, being involved in the process of developing our project, we anticipate that the stakeholders will be more prone to use the results that come out of it*, Hering says.

Scenarios can appear too rigid if there is no possibility for the stakeholders to change some variables in the subsets of scenarios. A way forward might be to allow these changes to see the effects of some management measures to varying degrees, under different scenarios.

Once the first modelling phase is done, the researchers will return to the stakeholders to discuss the models and possibly further adjust them.

– *The effect of this two-step process is that they will trust and relate to the tools we build*, Crowe says.

Communicating uncertainty

Based on solid facts, developed by valid methods and tested by those who have the right knowledge and experience, models and scenarios can be very useful tools for predictions. But they cannot be presented as hard-core facts.

– *As scientists, we are expected to give precise answers. That's of course very difficult in models, because the concept of models is to give clues in terms of probabilities. That's not easy to convey to a stakeholder. To do this in a good way, we do not necessarily need specific tools. But it is vital to use the time it takes, to explain well, listen carefully to the stakeholder's questions and, most importantly, to speak the language of the stakeholders*, Hering concludes.

If Crowe, Hering, and their partners succeed with their efforts, their scenarios will assist coastal managers and other actors in their efforts to improve water quality, restore aquatic ecosystems and to halt and reverse species decline.

For more information: the Land2Sea project

Key learning points

These key learning points are derived from (i) a search from the literature, (ii) the discussions and interviews with the researchers from the funded projects in Part 2, and (iii) the feedback received from the experts through the online consultation.

- Different types of scenarios can be used in many ways and be combined, as there is not a one size fits all to identify plausible trajectories for the fate of socio-ecosystems and biodiversity, and to communicate then to stakeholders.
- Many decision-support tools exist to fit scenario use across a diversity of contexts, scales, and geographies.
- Including decision/policy-makers and local practitioners make the scenarios relevant and enhance their chance of being used, especially when they are involved in an early phase of the work.
- More generally, scenarios are more realistic when knowledge collected from people on the ground is used in developing them.
- Allow much time initially for workshops, prepare participants for an iterative process, co-create narratives and define a "common working language".
- Policy/management decisions are easier to take when the possible outcomes are made clearer. Scenario planning clarifies the options and the risks.
- Scenarios might allow evaluation of whether policies are sufficient to achieve longer term objectives.
- Allow for visioning of a range of possible futures: "Either-or" is replaced by a "range of possibilities".
- Communicating uncertainty to non-scientists is difficult yet essential. They need some basic knowledge to be able to understand probabilistic methods and the meaning of scenarios.

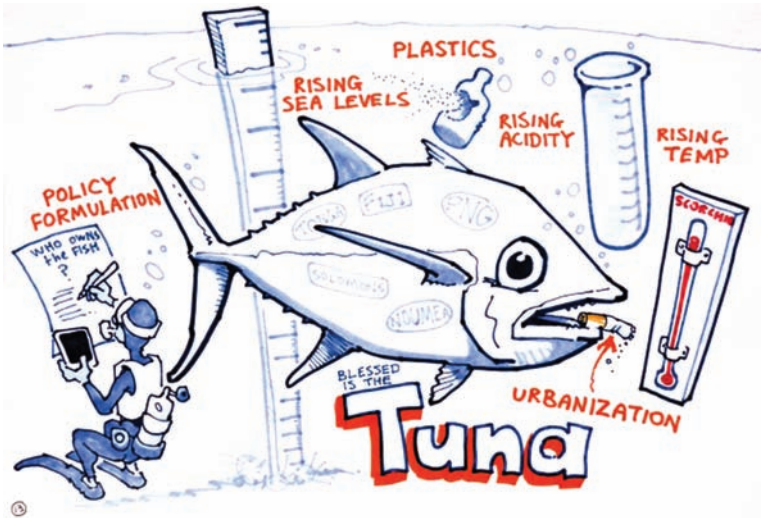


Figure 5. Scenarios can help assessing plausible futures for socio-ecosystems and biodiversity, accounting for multiple pressures and their complex interactions.
© Hoger Harvey, roger@rogerharvey.net

Part 3. Resource directory

This third part contains a selection of key resources and is publications cited in the text.

A directory of helpful resources on scenarios and models is available on the *BiodivERsA website.*

I. Key resources

The BiodivERsA Stakeholder Engagement Handbook. BiodivERsA (2014).

The BiodivERsA Stakeholder Engagement Handbook is a non-academic practical guide for researchers planning and carrying out research projects. It is designed to assist research teams identify relevant stakeholders to engage with in order to enhance the impact of their work. The Handbook draws upon exiting literature and presents case studies that provide clear, simple guidance, which considers 'why', 'who', 'when' and 'how' to engage.

https://www.biodiversa.org/706/download

The BiodivERsA guide on policy relevance of research and on effective science/policy interfacing in research proposals. BiodivERsA (2018).

The objective of the present guide is to help researchers to better understand what is policy relevance of research and be able to more efficiently identify the most relevant policies and policy-making bodies for a given research project. It complements the use of the Stakeholder Engagement Handbook to help researchers increase the quality of their research proposals in terms of policy relevance and may be used more generally as an introduction to the science-policy interface on biodiversity and ecosystem services.

https://www.biodiversa.org/1543

Biosphere Futures (2019).

Biosphere Futures is an online database that offers a global collection of place-based social-ecological scenario case studies. It provides a collection of socio-ecological scenarios that can be explored by selecting the ecosystem type, region, scale/scope, or SDG to which they relate. The aim is to facilitate assessment, synthesis and comparative analysis of scenario case studies.

www.biospherefutures.net

Global Biodiversity Outlook 5. CBD, Convention on Biological Diversity (2020).

The Global Biodiversity Outlook (GBO) is the flagship publication of the Convention on Biological Diversity. It is a periodic report that summarizes the latest data on the status and trends of biodiversity and draws conclusions relevant to the further implementation of the Convention. The fifth edition of the Global Biodiversity Outlook was officially launched in September 2020 and draws on various sources of information to provide an assessment of progress towards the implementation of the Strategic Plan for Biodiversity.

https://www.cbd.int/gbo/gbo5/publication/gbo-5-en.pdf

Scenarios For The 2050 Vision For Biodiversity. CBD, Convention on Biological Diversity (2017).

This present note has been prepared by the CBD Executive Secretary to provide relevant information concerning biodiversity-related scenarios and related scientific and technical infor-

mation on trends and projections towards 2050 and possible pathways to achieve the 2050 Vision of the Convention. It gives a wide-ranging overview of such projections and draws largely from the work prepared for the Global Biodiversity Outlooks, and other ongoing scenario-related work including that designed to inform future assessments under both the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

https://www.cbd.int/doc/c/4a22/3eba/a499b54091a1c1e22bb7b54e/sbstta-21-02-en.pdf

Catalogue of policy support tools. IPBES (2019).

The IPBES catalogue of policy support tools and methodologies is an evolving online resource with two main goals. The first goal is to enable decision-makers to gain easy access to information on policy support tools and methodologies to better inform and assist the different phases of policy-making and implementation. The second goal is to allow a range of users to provide input to the catalogue and assess the usability of tools and methodologies in their specific contexts, including resources required and types of outputs that can be obtained, thus helping to identify and bridge gaps with respect to available tools and methodologies.

https://ipbes.net/policy-support/search

The methodological assessment report on scenarios and models of biodiversity and ecosystem services. IPBES (2016).

The Scenarios and Models Assessment, published in 2016, and in particular its Summary for Policy Makers, presents a best-practice 'toolkit' for the use of scenarios and models in decision-making on biodiversity, human-nature relationships, and the quality of life. The 'toolkit' helps governments, private sector, and civil society to anticipate change - such as the loss of habitats, invasive alien species, and climate shifts - to reduce the negative impacts on people and to make use of important opportunities.

https://ipbes.net/assessment-reports/scenarios

ScenarioHub (2020).

ScenarioHub is a resource center developed by World Wildlife Fund and the Natural Capital Project, where scenario researchers and practitioners can learn more about spatial mapping and scenario analysis, find appropriate scenario tools using a tool database, and use the Scenario Generator Workspace for creating spatial scenario outputs.

http://scenariohub.net

Wayfinder (2018).

Wayfinder is a process guide for resilience assessment, planning and action in social-ecological systems. It is designed to balance the need for a legitimate, fair and transparent process through which knowledge is generated and decisions are made with the need for solid and relevant systems analysis that considers the complexity of sustainability challenges in the Anthropocene.

https://wayfinder.earth

II. References cited in this handbook

Addison, P. F. E., Rumpff, L., Bau, S. S., Carey, J. M., Chee, Y. E., Jarrad, F. C., McBride, M. F., & Burgman, M. A. (2013). Practical solutions for making models indispensable in conservation decision-making. *Diversity and Distributions*, *19*(5–6), 490–502. *https://doi.org/10.1111/ddi.12054*

Berg, C., Rogers, S., & Mineau, M. (2016). Building scenarios for ecosystem services tools: Developing a methodology for efficient engagement with expert stakeholders. *Futures*, *81*, 68–80. *https://doi.org/10.1016/j.futures.2015.10.014*

Bhagabati, N., Barano, T., Conte, M., Ennaanay, D., Hadian, O., McKenzie, E., Olwero, N., Rosenthal, A., Suparmoko, S. A., Shapiro, A., Tallis, H., & Wolny, S. (2012). *A green vision for Sumatra: using ecosystem services information to make recommendations for sustainable land use planning at the province and district level*. The Natural Capital Project, WWF-US and WWF-International. *https://woodsinstitute.stanford.edu/system/files/publications/GreenVision.pdf*

Biosphere Futures. (2019). *Biosphere Futures*. *https://www.biospherefutures.net*

Bullock, J., & Ding, H. (2018). *A guide to selecting ecosystem service models for decision-making: Lessons from Sub-Saharan Africa*. World Resources Institute. *https://wriorg.s3.amazonaws.com/s3fs-public/guide-selecting-ecosystem-service-model-decision-making_0.pdf*

CBD. (2017). *Scenarios For The 2050 Vision For Biodiversity* [Note by the Executive Secretary]. Convention on Biological Diversity (CBD). Twenty-first meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA), Montréal, Canada. *https://www.cbd.int/doc/c/4a22/3eba/a499b54091a1c1e22bb7b54e/sbstta-21-02-en.pdf*

Charron, I. (2014). *A Guidebook on Climate Scenarios: Using Climate Information to Guide Adaptation Research and Decisions*. Ouranos. *https://www.openchannels.org/sites/default/files/literature/A%20Guidebook%20on%20Climate%20Scenarios%20Using%20Climate%20Information.pdf*

Climate4impact. (2012). *What is the difference between the words scenario, projection, prediction and (weather) forecast?* E-Impact Portal. *https://climate4impact.eu/drupal/?q=scenarios_projections_predictions_forecasts*

DeAngelis, D. L. & Diaz, S. G. (2019). Decision-Making in Agent-Based Modeling: A Current Review and Future Prospectus. *Frontiers in Ecology and Evolution*, *6*(237), 1–16. *https://doi.org/10.3389/fevo.2018.00237*

de Guzman, A. B. (2016). A Fishery in Transition: Impact of a Community Marine Reserve on a Coastal Fishery in Northern Mindanao, Philippines. *Marine and Coastal Ecosystem Valuation, Institutions, and Policy in Southeast Asia*, 249–266. *https://doi.org/10.1007/978-981-10-0141-3_12*

Durham, E., Baker, H., Smith, M., Moore, E. & Morgan, V. (2014). *The BiodivERsA Stakeholder Engagement Handbook*. BiodivERsA. *https://www.biodiversa.org/706/download*

Eggers, J., Räty, M., Öhman, K., & Snäll, T. (2020). How Well Do Stakeholder-Defined Forest Management Scenarios Balance Economic and Ecological Forest Values? *Forests*, *11*(1), 86. *https://doi.org/10.3390/f11010086*

EIP-AGRI. (2016a). *Sustainable High Nature Value (HNV) farming: Final Report*. EIP-AGRI Focus Group on High Nature Value. *https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_fg_hnv_farming_final_report_2016_en.pdf*

Faivre, N., Fritz, M., Freitas, T., de Boissezon, B., & Vandewoestijne, S. (2017). Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges. *Environmental Research*, *159*, 509–518. *https://doi.org/10.1016/j.envres.2017.08.032*

Harrison, P. A., Harmáčková, Z. V., Aloe Karabulut, A., Brotons, L., Cantele, M., Claudet, J., Dunford, R. W., Guisan, A., Holman, I. P., Jacobs, S., Kok, K., Lobanova, A., Morán-Ordóñez, A., Pedde, S., Rixen, C., Santos-Martín, F., Schlaepfer, M. A., Solidoro, C., Sonrel, A., & Hauck, J. (2019). Synthesizing plausible futures for biodiversity and ecosystem services in Europe and Central Asia using scenario archetypes. *Ecology and Society*, *24*(2), 27. *https://www.ecologyandsociety.org/vol24/iss2/art27/*

Hudson-Doyle, E., Paton, D., & Johnston, D. (2018). Reflections on the communication of uncertainty: developing decision-relevant information. In K. Stock & D. Bunker (Eds.), *Proceedings of ISCRAM Asia Pacific 2018: Innovating for Resilience – 1st International Conference on Information Systems for Crisis Response and Management Asia Pacific* (pp. 166–189). New Zealand: Massey University. *http://idl.iscram.org/files/emmahudson-doyle/2018/1650_EmmaHudson-Doyle_etal2018.pdf*

IPBES. (2016a). *Summary for policymakers of the methodological assessment of scenarios and models of biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* (S. Ferrier, K. N. Ninan, P. Leadley, R. Alkemade, L. A. Acosta, H. R. Akɜakaya, L. Brotons, W. W. L. Cheung, V. Christensen, K. A. Harhash, J. Kabubo-Mariara, C. Lundquist, H. M. Obersteiner, G. Peterson, R. Pichs-Madruga, N. Ravindranath, C. Rondinini, & B. A. Wintle, Eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), Bonn, Germany. 32p. *https://doi.org/10.5281/zenodo.3235275*

IPBES. (2016b). *The Assessment Report on Pollinators, Pollination and Food Production: Summary for Policymakers* (S.G. Potts, V. L. Imperatriz-Fonseca, H. T. Ngo, J. C. Biesmeijer, T. D. Breeze, L. V. Dicks, L. A. Garibaldi, R. Hill, J. Settele, A. J. Vanbergen, M. A. Aizen, S. A. Cunningham, C. Eardley, B. M. Freitas, N. Gallai, P. G. Kevan, A. Kovaмcs-Hostyaмnszki, P. K. Kwapong, J. Li, X. Li, D. J. Martins, G. Nates-Parra, J. S. Pettis, R. Rader and B. F. Viana, Eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), Bonn, Germany. 36p. *https://doi.org/10.5281/zenodo.2616458*

IPBES. (2018). *IPBES Core Glossary*. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). *https://ipbes.net/glossary*

IPCC. (2013). *Definition of Terms Used Within the DDC Pages*. IPCC Data Distribution Centre (DCC). Accessed on 1 April 2020. *https://www.ipcc-data.org/guidelines/pages/definitions.html*

IPCC. (2014). *Climate Change 2014 Synthesis Report - Summary for Policymakers. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (R. K. Pachauri & L. A. Meyers, Eds.). Intergovernmental Panel on Climate Change (IPCC). *https://www.ipcc.ch/site/assets/uploads/2018/02/AR5_SYR_FINAL_SPM.pdf*

Joppa, L., & Pfaff, A. (2010). Reassessing the forest impacts of protection. *Annals of the New York Academy of Sciences*, *1185*(1), 135–149. *https://doi.org/10.1111/j.1749-6632.2009.05162.x*

Kosow, H., & Gaßner, R. (2008). *Methods of Future and Scenario Analysis. Overview, Assessment, and Selection Criteria*. German Development Institute / Deutsches Institut für Entwicklungspolitik (DIE). *https://www.die-gdi.de/studies/article/methods-of-future-and-scenario-analysis-overview-assessment-and-selection-criteria/*

Langsdale, S. (2008). Communication of Climate Change Uncertainty to Stakeholders Using the Scenario Approach. *Journal of Contemporary Water Research & Education*, *140*(1), 24–29. *https://doi.org/10.1111/j.1936-704x.2008.00025.x*

Lemaitre, F., Bridgewater, P., Eggermont, H., Gardner, S., Hueso, K., Niemelä, J., Paloniemi, R., Pereira Martins, I., Thornton, A., & Le Roux, X. (2018). *BiodivERsA guide on policy relevance of research and on effective science/policy interfacing in research proposals*. BiodivERsA. *https://www.biodiversa.org/1543*

Mahmoud, M., Liu, Y., Hartmann, H., Stewart, S., Wagener, T., Semmens, D., Stewart, R., Gupta, H., Dominguez, D., Dominguez, F., Hulse, D., Letcher, R., Rashleigh, B., Smith, C., Street, R., Ticehurst, J., Twery, M., van Delden, H., Waldick, R., … Winter, L. (2009). A formal framework for scenario development in support of environmental decision-making. *Environmental Modelling & Software*, *24*(7), 798–808. *https://doi.org/10.1016/j.envsoft.2008.11.010*

McClanahan, T. R., Marnane, M. J., Cinner, J. E., & Kiene, W. E. (2006). A Comparison of Marine Protected Areas and Alternative Approaches to Coral-Reef Management. *Current Biology*, *16*(14), 1408–1413. *https://doi.org/10.1016/j.cub.2006.05.062*

McKenzie, E., Rosenthal, A., Bernhardt, J., Girvetz, E., Kovacs, K., Olwero, N., & Toft, J. (2012). *Developing scenarios to assess ecosystem service tradeoffs*. World Wildlife Fund. *https://www.worldwildlife.org/publications/developing-scenarios-to-assess-ecosystem-service-tradeoffs*

Nicholson, E., Fulton, E. A., Brooks, T. M., Blanchard, R., Leadley, P., Metzger, J. P., Mokany, K., Stevenson, S., Wintle, B. A., Woolley, S. N. C., Barnes, M., Watson, J. E. M., & Ferrier, S. (2019). Scenarios and Models to Support Global Conservation Targets. *Trends in Ecology & Evolution*, *34*(1), 57–68. *https://doi.org/10.1016/j.tree.2018.10.006*

Olwero, N. (2019, December 11). *A Green Vision for Sumatra*. Biosphere Futures. Accessed on 2 April 2020. *https://www.biospherefutures.net/scenarios/Riau%2C-Jambi-and-West-Sumatra*

Oteros-Rozas, E., Martín-López, B., Daw, T. M., Bohensky, E. L., Butler, J. R. A., Hill, R., Martin-Ortega, J., Quinlan, A., Ravera, F., Ruiz-Mallén, I., Thyresson, M., Mistry, J., Palomo, I., Peterson, G. D., Plieninger, T., Waylen, K. A., Beach, D. M., Bohnet, I. C., Hamann, M., … Vilardy, S. P. (2015). Participatory scenario planning in place-based social-ecological research: insights and experiences from 23 case studies. *Ecology and Society*, *20*(4), 23. *https://doi.org/10.5751/es-07985-200432*

Palomo, I. (2020, February 17). *Participatory Scenario Planning in the Doñana Protected Area*. Biosphere Futures. Accessed on 1 April 2020. *https://www.biospherefutures.net/scenarios/Andaluc%C3%ADa*

Palomo, I., Martín-López, B., López-Santiago, C., & Montes, C. (2011). Participatory scenario planning for protected areas management under the ecosystem services framework: the doñana social-ecological system in southwestern Spain. *Ecology and Society*, *16*(1), 23. *https://www.ecologyandsociety.org/vol16/iss1/art23/*

Pereira, H. M., Leadley, P. W., Proença, V., Alkemade, R., Scharlemann, J. P. W., Fernandez-Manjarrés, J. F., Araújo, M. B., Balvanera, P., Biggs, R., Cheung, W. W. L., Chini, L., Cooper, H. D., Gilman, E. L., Guénette, S., Hurtt, G. C., Huntington, H. P., Mace, G. M., Oberdorff, T., Revenga, C., … Walpole, M. (2010). Scenarios for Global Biodiversity in the 21st Century. *Science*, *330*(6010), 1496–1501. *https://doi.org/10.1126/science.1196624*

Pichs-Madruga, R., Obersteiner, M., Cantele, M., Ahmed, M. T., Cui, X., Cury, P., Fall, S., & Kellner, K. (2016). Building scenarios and models of drivers of biodiversity and ecosystem change. In IPBES (Ed.), *The methodological assessment report on scenarios and models of biodiversity and ecosystem services* (pp. 83–118). Secretariat of the Intergovernmental Platform for Biodiversity and Ecosystem Services. *https://doi.org/10.5281/zenodo.3235428*

Raum, S. (2018). A framework for integrating systematic stakeholder analysis in ecosystem services research: Stakeholder mapping for forest ecosystem services in the UK. *Ecosystem Services*, *29*, 170–184. *https://doi.org/10.1016/j.ecoser.2018.01.001*

Riahi, K., van Vuuren, D. P., Kriegler, E., Edmonds, J., O'Neill, B. C., Fujimori, S., Bauer, N., Calvin, K., Dellink, R., Fricko, O., Lutz, W., Popp, A., Cuaresma, J. C., KC, S., Leimbach, M., Jiang, L., Kram, T., Rao, S., Emmerling, J., … Tavoni, M. (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. *Global Environmental Change*, *42*, 153–168. *https://doi.org/10.1016/j.gloenvcha.2016.05.009*

Shell. (2008). *Scenarios: An explorer's guide*. Shell International BV. *https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/new-lenses-on-the-future/earlier-scenarios/_jcr_content/par/expandablelist/expandablesection_842430368.stream/1519772592201/f5b043e97972e369db4382a38434d4dc2b1e8bc4/shell-scenarios-explorersguide.pdf*

Sitas, N., Harmáčková, Z. V., Anticamara, J. A., Arneth, A., Badola, R., Biggs, R., Blanchard, R., Brotons, L., Cantele, M., Coetzer, K., DasGupta, R., den Belder, E., Ghosh, S., Guisan, A., Gundimeda, H., Hamann, M., Harrison, P. A., Hashimoto, S., Hauck, J., … Valle, M. (2019). Exploring the usefulness of scenario archetypes in science-policy processes: experience across IPBES assessments. *Ecology and Society*, *24*(3), 35. *https://www.ecologyandsociety.org/vol24/iss3/art35/*

Star, J., Rowland, E. L., Black, M. E., Enquist, C. A. F., Garfin, G., Hoffman, C. H., Hartmann, H., Jacobs, K. L., Moss, R. H. & Waple, A. M. (2016). Supporting adaptation decisions through scenario planning: Enabling the effective use of multiple methods. *Climate Risk Management*, *13*, 88–94. *https://doi.org/10.1016/j.crm.2016.08.001*

Stone, R. J. (2012). *Human Factors Guidance for Designers of Interactive 3D and Games-Based Training Systems*. Human Factors Integration Defence Technology Centre Publication. *https://www.birmingham.ac.uk/Documents/college-eps/eece/research/bob-stone/human-factors-guidance.pdf*

UNU-IAS. (2010). *Satoyama – Satoumi Ecosystems and Human Well-being: Socio-ecological Production Landscapes of Japan – Summary for Decision Makers*. United Nations University. *https://collections.unu.edu/view/UNU:6300#viewAttachments*

Van Berkel, D. B., & Verburg, P. H. (2012). Combining exploratory scenarios and participatory backcasting: using an agent-based model in participatory policy design for a multi-functional landscape. *Landscape Ecology*, *27*(5), 641–658. *https://doi.org/10.1007/s10980-012-9730-7*

Van Vuuren, D. P., Kok, M. T. J., Girod, B., Lucas, P. L., & de Vries, B. (2012). Scenarios in Global Environmental Assessments: Key characteristics and lessons for future use. *Global Environmental Change*, *22*(4), 884–895. *https://doi.org/10.1016/j.gloenvcha.2012.06.001*

VOLANTE. (2015). *The EU-funded VOLANTE (Visions Of LANd use Transitions in Europe) project*. *http://www.volante-project.eu*

Waite, R., Kushner, B., Jungwiwattanaporn, M., Gray, E., & Burke, L. (2015). Use of coastal economic valuation in decision making in the Caribbean: Enabling conditions and lessons learned. *Ecosystem Services*, *11*, 45–55. *https://doi.org/10.1016/j.ecoser.2014.07.010*

Willcock, S., Hooftman, D., Sitas, N., O'Farrell, P., Hudson, M. D., Reyers, B., Eigenbrod, F., & Bullock, J. M. (2016). Do ecosystem service maps and models meet stakeholders' needs? A preliminary survey across sub-Saharan Africa. *Ecosystem Services*, *18*, 110–117. *https://doi.org/10.1016/j.ecoser.2016.02.038*

The BiodivScen project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776617

For more information:
BiodivScen Coordinator
Xavier Le Roux
xavier.leroux@fondationbiodiversite.fr
Ph.: +33 (0) 6 31 80 38 20

BiodivScen Secretariat
Cécile Jacques
cecile.jacques@fondationbiodiversite.fr
Ph.: +33 (0) 1 80 05 89 41

Fondation pour la Recherche sur la Biodiversité
195, rue Saint Jacques
75005 Paris, France

Websites
www.biodiversa.org
www.belmontforum.org