United Nations Educational, Scientific and Cultural Organization

CANADIAN COMMISSION FOR UNESCO

United Nations Educational, Scientific and Cultural Organization

Man and the Biosphere Programme

Assessing Ecosystem Services in UNESCO Biosphere Reserves

A Concept Paper prepared for the Canadian Commission for UNESCO

By Liette Vasseur and Robert Siron

Ottawa, Canada, March 2019

To quote this article:

VASSEUR, L. & SIRON, R. ‘‘Assessing ecosystem services in UNESCO biosphere reserves’’, the Canadian Commission for UNESCO, March 2019.

Cover photo: Nuu-chah-nulth photographer Melodie Charlie, Clayoquot Biosphere Trust

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Acknowledgements

We would like to thank Bernal Herrera-Fernández from the Foundation for the Development of the Central Volcanic Mountain Range (Fundecor), Costa Rica, Pamela McElwee from Rutgers, the State University of New Jersey, United States, and Geneviève Poirier, Director of Conservation, Mont Saint-Hilaire Biosphere Reserve, for reviewing this document. Their comments were greatly appreciated.

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Glossary of Terms

Aichi Biodiversity Targets - The Aichi Biodiversity Targets are part of The Strategic Plan for Biodiversity 2011-2020 – A ten-year framework for action by all countries and stakeholders to save biodiversity and enhance its benefits for people. Adopted in 2010 at the Conference for the Parties for the Convention on Biological Diversity in Nagoya, Aichi Prefecture, Japan, the plan includes 20 biodiversity targets, known as the Aichi Targets, which are to be achieved by 2020 to reverse the global decline in biodiversity.

Ecosystem - An ecosystem includes all living things in a given area, as well as their interactions with each other, and with their non-living environments (weather, earth, sun, soil, climate, and atmosphere). Each organism has a role to play and contributes to the health and productivity of the ecosystem as a whole.

Ecosystem Approach - Ecosystem-based management is an integrated management approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation.

Equitable Payments for Ecosystem Services - Payments for ecosystem services occur when a beneficiary or user of an ecosystem service makes a direct or indirect payment to the provider of that service. The idea is that whoever preserves or maintains an ecosystem service should be paid for doing so in a way that recognizes and balancing the rights and interests of different stakeholders.

Material NCP - Material Nature's Contributions to People (NCP) are substances, objects, or other material elements from nature that directly sustain people's physical existence and material assets. They are typically physically consumed in the process of being experienced—for example, when organisms are transformed into food, energy, or materials for ornamental purposes.

Nature-Based Solutions - Nature-based Solutions (NbS) are "actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits". (IUCN)

Non-Material NCP - Non-material NCP are nature's effects on subjective or psychological aspects underpinning people's quality of life, both individually and collectively, such as those that provide opportunities for recreation, inspiration, and spiritual experiences.

Paris Agreement - At COP 21 in Paris, on 12 December 2015, Parties to the United Nations Framework Convention on Climate Change reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 degrees Celsius.

Periodic Review of UNESCO Biosphere Reserves - The periodic review is an important event in the life of a biosphere reserve. It enables a review, every ten years, of the functioning, zoning, and scale of the biosphere

reserve as well as the involvement of the populations living in the site. The periodic review represents an opportunity to carry out a qualitative survey of the actions implemented and their results. It's a time to take stock of progress made by the biosphere reserve, especially as concerns the updating of knowledge, skills and expertise in resource and ecosystem management.

Regulating NCP - Functional and structural aspects of organisms and ecosystems that modify environmental conditions experienced by people, and/or sustain and/or regulate the generation of material and non-material benefits. These NCP include, for example, water purification, climate regulation, or soil erosion regulation. They are often not experienced directly by people.

Sustainable Development Goals (SDGs) - These are 17 goals that were adopted by all United Nations Member States in 2015. They compose the 2030 Agenda for Sustainable Development, with the ultimate goal of "peace and prosperity for people and the planet, now and into the future" (https://sustainabledevelopment.un.org). They replace the eight Millennium Development Goals (MDGs) that mainly aims to reduce poverty. It is important to note that the SDGs are for all countries, not only developing countries as it was with the MDGs. They also include poverty reduction (#1), end hunger (#2), healthy living (#3), education (#4), and gender equality (#5) but also add emphasis on climate change (#13), water (#14) and land (#15) protection and sustainability.

Abbreviations

BR	Biosphere Reserve
EbA	Ecosystem-based adaptation
ES	Ecosystem services
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IUCN	International Union for Conservation of Nature
MAB	UNESCO's Man and the Biosphere Programme
MDG	Millenium Development Goals
NCP	Nature's contributions to people
SDG	Sustainable development goal
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization

Introduction

A biosphere reserve (BR) is a place where conservation of biodiversity and sustainable development are promoted through different functions located within three specific zones, namely conservation (or core), buffer and transition zones, which include protected areas and communities. It can be seen as a living laboratory where the spirit promoted by the United Nations (UN) Agenda 2030 can be lived through actions at the local level.

A variety of tools have been used to communicate about BRs, their mandates and roles, as well as to monitor and assess the activities that happen within them. Some tools also attempt to evaluate their benefits to society. Recently, the concept of ecosystem services (ES) was introduced in the periodic reviews of BRs as a way to monitor and assess the "health" of the ecosystem and to better understand how BRs function to serve nature and society. ES are particularly amenable to the BR framework because they can capture benefits of both protected lands and "used" or managed land, as well as the trade-offs and interactions among these different zones of use.

Ecosystem services assessment within a BR supports the reporting process and serves as a monitoring tool when it is carried out on a regular basis and built on local, traditional, and scientific knowledge. Ecosystem services are important to understand in BRs as they can help define the types of management needed in the various zones and can be linked to various values that a BR wants to prioritize such as cultural, social or health values. In this paper, we briefly introduce the concept of ES, explain how it relates to BRs and their beneficiaries, and then propose a way to assess and gradually monitor ES according to the objectives and priorities of each BR.

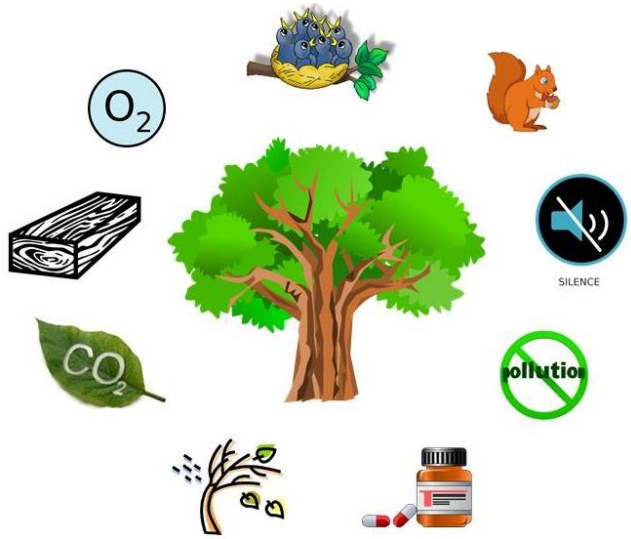
1. Ecosystem services: assessing / valuing nature's contributions to people

1.1 What are ecosystem services?

A service is defined according to the Oxford Dictionary as "the action of helping or doing work for someone" (https://en.oxforddictionaries.com/definition/service). When we think about this, a garbage collector is providing an important service to all residents in a community, the mailperson delivering the mail at home has a similar function. These are all services that we connect to because they are performed by humans for the services of other humans.

Ecosystems are doing the same: they provide services to all living things, including humans. Trees in a forest grow and provide benefits for wildlife and humans. A tree can support a bird's nest and produce nuts to feed squirrels. For humans, trees can provide many benefits and services such as timber, medicine, tannin, *etc*. A tree also provides oxygen and reduces wind speed. When strategically placed along highways, trees can reduce noise and air pollution. They also reduce the "heat island" effect in big cities during extreme heat waves. Globally, trees are important for capturing carbon dioxide due to greenhouse gas emissions, and in so doing they play an important role in climate change mitigation. This analogy is not limited to a single tree but in fact to the ecosystems in which they grow. Tree-based ecosystems, such as mangroves or forests, when healthy, therefore have very important functions such as protection against storms or high winds.

Trees provide multiple ecosystem services for wildlife and humans from timber supplies to air pollution reduction to nesting sites for birds



In a forest, there are not only trees but also many other plants such as ginseng, wild leek, wild ginger, which are often consumed by humans or by other animals. These too are providing goods and services. Animals living in the forest (e.g. partridge, deer) can be consumed and provide goods for people. A single forest can thus provide many goods or services to a community. It is the same for a stream, a lake or a coastal area where people can drink water, catch a fish, and enjoy the outdoors. Again, these are all benefits that people receive from these places. They are what we call ecosystem services.

Some ES are derived primarily from the natural environment such as an unmanaged forest, a wetland or a river, providing carbon storage, habitat for biodiversity or high-quality water. Other services come from managed ecosystems such as parks and protected reserves which provide opportunities for leisure, or

agricultural lands, which produce food. Both types of ecosystems, managed and natural, can also provide many other ES, some being less tangible than food or water, such as pollination, disease and pest control, climate regulation, spirituality and aesthetic beauty. In brief, ES are derived from the ecosystem functioning and benefit humans in their living and well-being.

> ***Ecosystem services (ES)***
> *"Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits". MEA 2015*

1.2 Categories of services to illustrate the diversity of their value / contribution / benefit

Ecosystem services have recently been placed into three major categories, although some literature will include four categories. The first category of ES is called <u>provisioning</u> services. Potatoes from an agricultural field, berries harvested in grassland or a fish caught from a lake or the ocean are all provisions coming from these ecosystems. They are often called goods and services, because we consume them.

> ***Provisioning** ecosystem services are things that are consumed, such as food or materials*

Produce at a farmer's market in Frontenac Arch Biosphere Reserve, Canada (Credit: L. Vasseur)

Wood for building from native trees in Eucador: seedlings are planted to replace trees harvested (Credit: L. Vasseur)

The second category includes <u>supporting and regulating</u> services (although historically they were put into two distinct categories (see: Costanza *et al*., 2017 for more information). When we state that a forest reduces winds, noise or pollution, or produces oxygen (which we absolutely need), we are talking about these types of services. They support our lives as well as the lives of all other species on earth. Many of these services are not well understood unless there is a catastrophic damage or a natural disaster. For example, the removal of mangroves along a coast or a forest on a side of a mountain, can lead to major disasters when there is a storm, including flooding and erosion along the coast or mudslides from the side of a mountain. These services are often not valued because their benefits to people are indirect, but they are hugely important. For example, if we didn't have decomposers such as earthworms, bacteria and fungi in the soil, organic matter from dead leaves or animals would accumulate, and carbon and nutrients would not be recycled. These services are considered critical because they support the ecosystem capacity to provide

other services from which people benefit more directly. For example, soil formation is not, in and of itself, important to people, but without it, farmers would quickly lose their ability to produce enough food. Think about when there is a strike of the garbage collectors, the accumulation of waste is quite incredible in cities. It is the same type of services that these micro-organisms living in the soil are providing. Without them, it would mean no soil formation, the same soil needed to support the growth of vegetables and trees.

Forests and wetlands provide ***supporting and regulating*** *ecosystem services by reducing flooding*

View of the Amazon in Ecuador on a visit to the Amaroon tribe (Credit: L. Vasseur)

Dune and salt marshes in Kouchibouguac National Park form a buffer against storms (Credit: L. Vasseur)

The third category is directly connected to human benefits as it relates to recreation, culture, education, spirituality, etc. They are called cultural services and are also essential for physical, mental and emotional well-being. They are linked to how we perceive our environment. It may be as simple as a municipal park where people enjoy walking or participating in recreational activities to relax and taking some time outdoors. It may be closely tied to spiritual beliefs and practices, such as the Great Bear Rainforest in British Colombia.

Cultural *ecosystem services are essential for physical, mental and emotional well-being or for expressing spiritual beliefs*

Sacred old tree for prayer in Panchase, Hymalaya, Nepal (Credit: L. Vasseur)

1.3 Nature's contribution to people, for a greater importance of culture

In its 2018 meeting, the International Panel on Biodiversity and Ecosystem Services (IPBES) endorsed the idea of "nature's contributions to people" (NCP) of which ES are a part. It broadens the ES concept to focus not only on the economics of ES but to also consider other types of benefits. For example, food is often considered to be primarily a provisioning ecosystem service, however food is fully of symbolic meaning well beyond physical survival (Diaz *et al*. 2018).

Nature's contribution to people (NCP)

"Nature's contributions to people (NCP) are all the contributions, both positive and negative, of living nature (i.e. diversity of organisms, ecosystems, and their associated ecological and evolutionary processes) to the quality of life for people." IPBES

Appendix 1 describes how Diaz *et al.* (2018) have suggested a revised terminology to view ES in a more holistic view, including the importance of the cultural context. In this document, we have adjusted the way ES are presented as a function of this new representation. The most important difference between the ES frameworks previously proposed and the NCP concept is the greater importance that is put on cultural contributions of nature to people. In previous frameworks, the so-called cultural ES was the category that had been the least studied and described because the study of ES has often been linked to monetary values.

The ES/NCP in this guide are described in the Diaz paper (Diaz *et al.* 2018). Appendix 3 presents the list of the 18 categories of NCP organized into three broad groups: regulating NCP, material NCP, and non-material NCP. There is some overlap with the three categories of ES described above, but the NCP approach is considered to be more inclusive, recognizing a broad range of views.

2. Ecosystem services … a tool to connect people and nature

2.1 Reconnecting people and nature

Over the years, the impacts and complexity of human activities have changed and increased. These changes have had numerous effects on the health and well-being of communities, and have resulted in two phenomena. The first is that ecosystems have been transformed, causing irreversible loss of biodiversity leading to the decline of ecosystem functions and services. The second is that, in addition to considering nature only at the utilitarian level, we are progressively disconnected from it and we therefore have a harder time understanding the impacts of ecosystem degradation on our own lives.

The concept of ecosystem services / nature's contributions to people has been put forward in order to convince decision-makers that it is essential to slow down the degradation of natural environments on a territorial scale. It is an awareness of the importance of the multiple complex contributions of natural environments to the well-being of individuals and communities.

2.2 A tool for decision making

Understanding the roles that ES play in BRs is important so that they can be protected and, when necessary, restored. This is especially needed when BRs are making decisions about the management or exploitation of ecosystems. Several research groups are attempting to provide empirical data on the economic value of ecosystems and biodiversity (Kermagoret & Dupras, 2018). They aim to build a compelling case for conservation through the integration of the monetary value of ecosystems and the benefits they bring to current economic measurement instruments. However as mentioned above, a monetary value cannot always be applied to ES/NCP.

Idea to retain: ES/NCP is an interesting tool to become aware of the importance of establishing a connection between man and nature, which:

- *Aims to raise awareness of the importance of ecosystems and develop a closer relationship with nature in order to promote the protection of the natural environment for the current and future well-being of communities*
- *Offers a positive alternative to alarmist speeches about environmental degradation*
- *Proposes a positive vision of the territory and the future in which individuals and communities will want to invest and participate.*

Since the services provided by ecosystems are based on the quality, presence and distribution of natural environments, their analysis requires a set of spatial data covering the entire area of interest. Mapping approaches make it possible to visualize analyses of ES of the area and can make it easier to understand the results. Decision-makers can also use mapping to design spatial policies and predict the effect of land-use policies on a community's ability to provide goods and services.

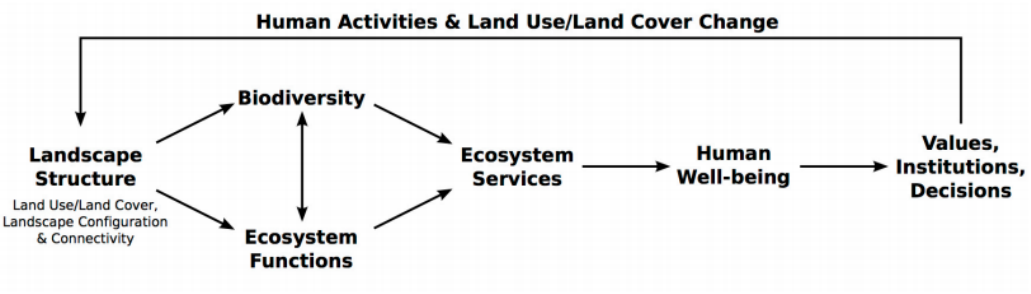


Figure 1. Landscape structure affects both levels of biodiversity and the different ecosystem functions present in landscapes. This in turn affects all types of ecosystem services (e.g., provisioning, regulating, and cultural), human well-being, and eventually social values, institutions, and decisions. These social changes will affect people's actions in the landscape, in turn changing how they use the land and affect landscape structure. (From Mitchell et al. 2015, with permission).

2.3 Developing a common vision for biosphere reserves

The current action plan for the UNESCO (United Nations Educational, Scientific and Cultural Organization) Man and the Biosphere (MAB) programme, the Lima Action Plan (UNESCO 2017), underlines that "Biosphere Reserves [are] recognized as sources and stewards of ecosystem services." Biosphere reserves are required to report on ES within their 10-year periodic review (see Appendix 2).

The ES/NCP approach enables BRs to work collaboratively with stakeholders within their BR to discuss and realize the importance of ES/NCP and the impact of past, present and future land-use planning decisions. It helps with discussions about landscape management and spatial planning, and helps BRs monitor the biodiversity and ecosystem health (Figure 1, Mitchell *et al.* 2015). A collaborative and step-by-step approach improves community engagement by providing information about how land-use activities and changes to landscape structure are likely to affect biodiversity and ES/NCP:

The approach

- Improve landscape understanding of biodiversity and ecological services
- Highlight the importance of protecting and connecting natural environments
- Develop a shared and more sustainable vision of the BR territory
- Optimize the benefits of scientific research through consultation and participation of BR stakeholders.

Idea to retain: ES/NCP enables local stakeholders to understand the contributions of ES/NCP in
– Landscape management
– Spatial planning

3. Biosphere Reserves: sources and stewards of ecosystem services

As we have just described, ecosystems are the natural capital that provide the necessary functions and services for peoples' lives and well-being, such as climate regulation, carbon sequestration, soil fertility, pollination, filtering pollutants, providing clean water, flood control, recreation, and aesthetic and spiritual values, among others. It is important to realise that many ecosystem functions such as a relaxing atmosphere, aesthetics, basic subsistence, traditional medicinal plants, *etc.* are also important despite not having economic values. Other principles related to solidarity, equality, civil rights, cultural practices, *etc*. are important to society and are not captured in ES but are discussed in NCP. These contributions are important and are at the heart of what is also valued in BRs – the NCP approach is therefore appropriate in BRs.

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Man and the Biosphere Programme

A New Roadmap for the Man and the Biosphere (MAB) Programme and its World Network of Biosphere Reserves

MAB Strategy (2015-2025)
Lima Action Plan (2016-2025)
Lima Declaration

The Man and the Biosphere (MAB) programme is part of UNESCO's Natural Sciences sector → It is implemented by the World Network of Biosphere Reserves → The current action plan for the MAB programme is the Lima Action Plan

3.1 Importance of ecosystem services for achieving the sustainable development goals

Challenges such as climate change and land degradation make the importance of studying ES even more important. In September 2015, the UN adopted the Agenda 2030 Sustainable Development Goals (SDGs). The SDGs emphasise the need to not only focus on economic growth but to also integrate social and environmental considerations into decision-making and resource management. The seventeen SDGs demonstrate the need for better protection of our ecosystems to achieve some of the basic goals such as SDG2: ending poverty and achieving food security (Figure 2, Vasseur *et al.* 2017).

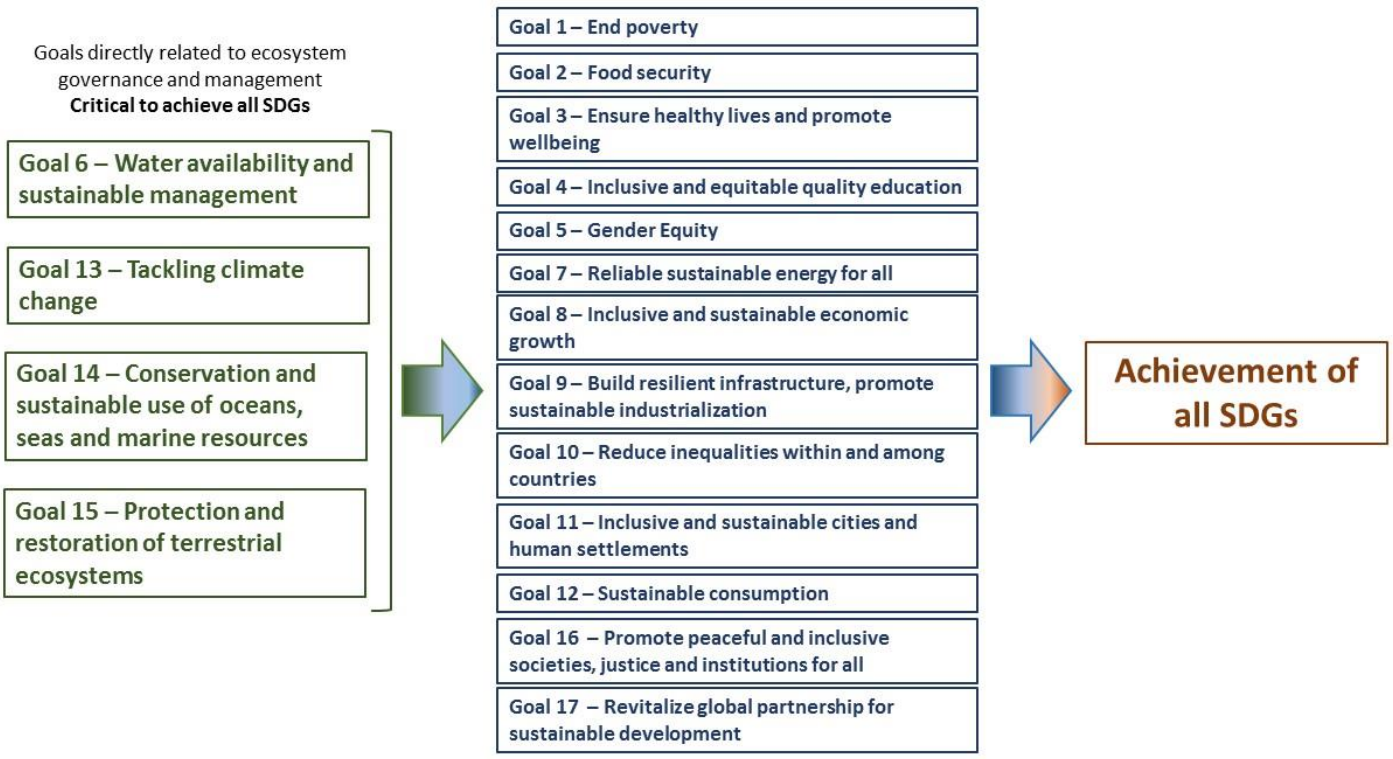


Figure 2: Direct and indirect influence of ecosystem governance and management on the achievements of sustainable development goals. Source: Vasseur et al. (2017), reproduced with permission.

In recent years, the UN, the International Union for Conservation of Nature (IUCN), and UNESCO have all in suggested that BRs can be considered as model sites for learning how SDGs can be implemented and assessed since periodic reviews allow them to directly measure changes related to SDGs over time. The main reason is that BRs contribute to defining new ways of understanding and demonstrating how humans can live sustainably, in harmony with nature, and by being stewards of the ES within their BRs. They are also related to many other international conventions to which UNESCO members are subscribed, such as the United Nations Declaration on the Rights of Indigenous Peoples, the Convention for Biological Diversity's Aichi Biodiversity Targets, and the United Nations Framework Convention on Climate Change's Paris Agreement.

In the global context of climate change, ES also play important roles as they help local communities reduce their vulnerabilities and adapt to climate change, through what is called Ecosystem-based Adaptation (World Bank, 2009; IUCN, 2009). For example, the Intergovernmental Panel on Climate Change clearly recognizes the interactions between biodiversity loss and climate change (i.e. biodiversity loss is considered to be a key risk for climate-related issues) and how ES contribute to both mitigation and adaptation to climate change (IPCC, 2012; 2014). In this context, ES within BRs should be a focus for any climate change adaptation strategy implemented at the local or regional scale (BAWG, 2018).

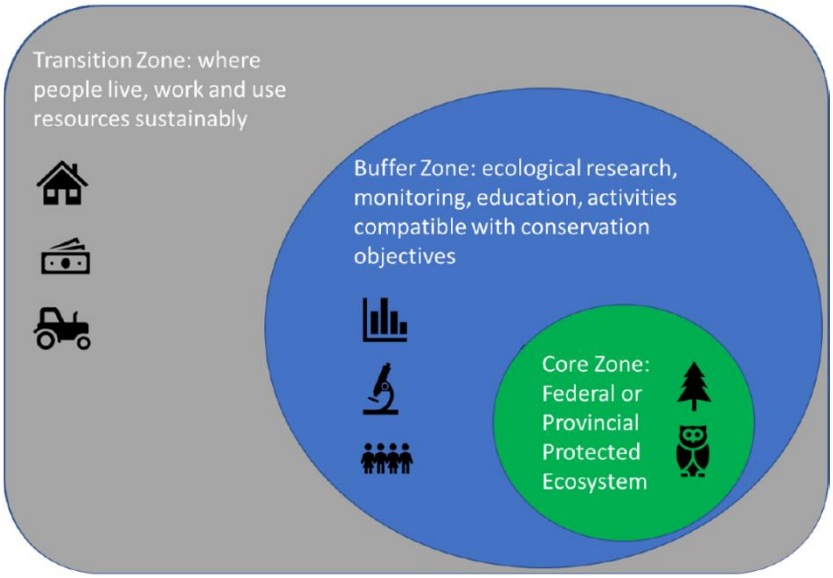
It is clear that it is not possible for a BR to define and evaluate all the ecosystem services in their BR. Therefore, it is important to figure out the best way to identify, assess and report on some ES: those that are the most important according to their priorities and objectives of each specific BR.

3.2 Ecosystem services assessment: a biosphere reserve approach

How BRs can deal with assessing ES will vary greatly. BRs have three zones so there is a need to consider the different ways in which ES may be affected in each of these zones.

The **core zone** serves the conservation role of the BR by protecting biological diversity in natural terrestrial and/or aquatic ecosystems. These ecosystems provide many services (Appendix 3) and are often the most ecologically significant areas of the BR.

Ecosystem services in the three zones may need to be assessed separately or together, depending on the priorities and objectives of the biosphere reserve



The **buffer zone** adjacent to the core area aims to promote sustainable development using an ecosystem-based approach and ecological principles (as generally supported by IUCN, UNESCO and other UN organizations). While human use influences what is happening at the ecosystem level, biodiversity conservation, for example, remains one objective that can help connect species habitats for their long-term survival. Promoting and maintaining ES in the buffer zone is also important to ensure sustainable development. Research and monitoring as well as the development of innovations may be ways to improve NCP through what is called nature-based solutions (IUCN 2016). The Lima Action Plan (UNESCO 2017), for example, proposes actions such as equitable payment for ecosystem services as a way to enhance ES that may be threatened by some human activities such as deforestation or agricultural expansion.

The **transition zone** should also be an area where resources are used sustainably. Ecosystem services such as water filtering and purification by wetland creation or climate regulation through tree planting in residential developments can be promoted in this zone.

The unique structure of BRs allows them to provide a variety of ES. The design of the three zones helps provide a variety of services, functions and contributions. Some are provided primarily by protected areas (e.g. recreation or carbon storage). Others are provided primarily by working areas (e.g., sustainable forestry or agriculture), while others are provided in between (e.g. nutrient regulation, habitat for biodiversity or ecotourism). It is important to remember the complex ways in which ES interact over a larger scale. When looking at the BR as an entire system, some ES, such as water purification coming from a wetland in the core zone, may provide services to the other zones. The boundaries between the zones are not real boundaries as far as ES/NCP are concerned and ES/NCP have influences beyond the BR boundaries.

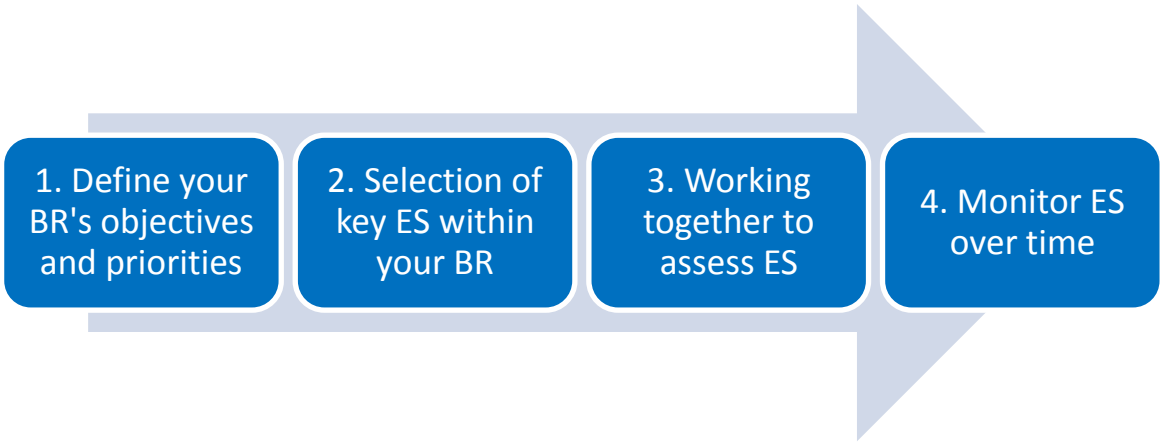
Approaches to assessing ES/NCP in BRs will vary greatly. Ecosystem services in the three zones may need to be assessed separately or together, depending on the priorities and objectives of the biosphere reserve. We recommend that ES/NCP should be assessed through the lens of the priorities and objectives of the BR instead of trying to capture all the ES of each zone. While assessing all ES would be interesting, it is usually not feasible unless a very large detailed research project is being conducted (Dee *et al.* 2017).

Understanding the roles that ES/NCP play in BRs is important for their protection and, when necessary, restoration. This is especially important when BRs are working with other stakeholders on the management or exploitation of ecosystems in any of the three zones. For example, should a forest adjacent to a river be cut to add a few extra houses in a residential subdivision? Knowing the extent of the services that that forest provides, such as buffering against storms and flooding, reducing noise and air pollution, extreme heat reduction and carbon storage, and/or being attractive and enjoyed by hikers and residents, can help engage all stakeholders and inform collective decision-making. Ultimately, the decision made will depend on the zone in which the forest is located and the relevant rights-holders. However, knowing what is there in terms of the most important ES/NCP in a BR can significantly educate and inform decision makers.

In Canada (and some other countries), it is important for BRs to also recognize Indigenous Peoples' rights and therefore ES/NCP should consider traditional knowledge and cultural practices and the right to be consulted. In fact, Indigenous Peoples bring a wealth of knowledge and ways of knowing that contribute significantly to the understanding of our natural environments and in ES/NCP assessment.

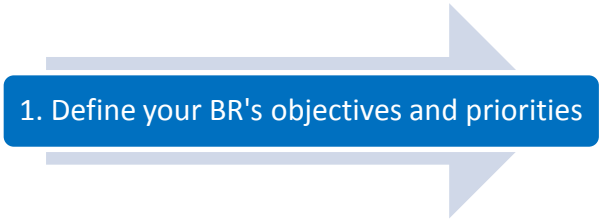
4. A proposed step-by-step approach to define and assess Biosphere Reserves' ecosystem services

Since ecosystems are complex systems to study and assess, the proposed approach is collaborative, involving multiple stakeholders, and considers both local knowledge and scientific evaluation. There are several methods that can be used, some being complex and very demanding (especially for communities and non-profit organizations with limited resources), but others are achievable in the absence of experts. To assist, we have added examples from two BRs in Canada: Mont St. Hilaire (Box 1) and Clayoquot Sound (Box 2) UNESCO Biosphere Reserves.



The proposed steps to defining and assess ecosystem services in a biosphere reserve

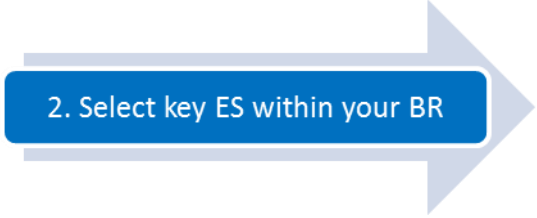
4.1 Define your biosphere reserve's objectives and priorities



Each BR should define its objectives and priorities when submitting the BR establishment documents and later on in their periodic review documents. These will be specific to each BR with some placing more importance on conservation measures and others on sustainable development. It is helpful to know what these objectives mean to all BR stakeholders or organization members (here we consider stakeholders as anyone interested in helping in the BR activities and this includes all cultures and age groups).

For example, in the Clayoquot Sound UNESCO Biosphere Region (Box 2), one of the core priorities is healthy communities (SDG3) and salmon stewardship (SDG 14 and 15). Salmon has important significance for community sustainability, conservation and cultural value. This component would therefore be assessed as a NCP that benefits local communities, as elaborated in Appendix 3. For Mont St Hilaire (Box 1), the main priority is habitat creation and maintenance (SDG15), and this is done through various activities such as land acquisition for conservation and promoting nature literacy (SDG4) by engaging with citizen scientists.

4.2 Select key ecosystem services within your biosphere reserve



As a group, stakeholders would then be able to discuss which of the 18 ES categories (Appendix 3) would be essential to assess to have a good understanding on the contribution of this ecosystem component to the BR as defined in the first step. This may require members to make diagrams or describe, first qualitatively and hopefully moving to more a quantitative assessment over time, how this specific priority/objective and its

components relate to the various ES and priority SDGs. People doing such an exercise should not get discouraged if data are unavailable, it is expected that not everything can be completely assessed. Data availability, key partners, and knowledge (experts, community, round table, *etc*.) will greatly influence the depth of the assessment and this can change over time.

Box 1: Mont St.-Hilaire Biosphere Reserve case study

The Mont Saint-Hilaire Biosphere Reserve, designated in 1978, is presented here as a test case to explore how the proposed ES assessment framework can be applied to individual BR's goals and objectives.

Mont-Saint-Hilaire Biosphere Reserve

In 1978, the Mont Saint-Hilaire Biosphere Reserve was the first Biosphere Reserve to be designated as such in Canada. When it was created, the Mont Saint-Hilaire Biosphere Reserve primarily encompassed Mont Saint-Hilaire, home to one of the oldest forests in southern Quebec. The forest boasts around 1235 species of plants, mammals, birds, amphibians, and reptiles, 70 of which are rare of threatened. Now, the Mont Saint-Hilaire Biosphere Reserve spans over an area that includes 8 municipalities (29 500 ha). Within these municipalities, projects are conducted yearly to protect and restore the region's natural areas, to enhance the forest corridors and to plan responsible urbanization while taking natural environments into account and encourage agritourism and local agriculture.

Vision statement

Since its inception, the Centre de la Nature seeks to inspire and encourage local people and organization to invest in conservation of the natural areas in and around Mont Saint-Hilaire. The centre currently provides access to approximately 300,000 visitors annually. The formally stated mission is: "Que la Réserve de biosphère du mont Saint-Hilaire soit un territoire constitué d'un important réseau d'aires protégées diversifié, connecté et accessible où les collectivités s'investissent pour créer un milieu de vie inspirant, viable et riche de nature" [The mission of the Nature Centre is to conserve the natural habitats of Mont Saint-Hilaire and the Biosphere Reserve, to offer a privileged contact with nature to population, and to advance knowledge in natural environments].

Protecting natural habitat in a rapidly suburbanizing region

Aligning with this mission, perhaps the most important ecosystem service is: Habitat conservation, creation and maintenance. The Mont Saint-Hilaire Biosphere Reserve sees one of its primary goals to be protection of habitat and other natural areas. In the context of a rapidly suburbanizing, agricultural region, protection of natural habitat from further encroachment is a key goal.

Understanding, and promoting, the ecosystem services provided by this natural habitat, including habitat itself, carbon storage, pollination (through provision of habitat for pollinators), regulation of air quality, water quality, and climate, as well as regulation of flooding events, are a critical means by which the Mont Saint-Hilaire Biosphere Reserve can achieve its goals of protecting the natural habitat.

Finally, when the local population participates in measuring and evaluating the services provided, it is also involved in the process and participates in the BR's mission, which is to educate the local population on the Biosphere Reserve ecosystems and their importance.
To find out more: http://centrenature.qc.ca/proteger/

For example, in the Clayoquot Sound case study (Box 2), salmon would be related to ES #12 - Food and feed, and ES #17 - Supporting identities; e.g. for First Nations. It may also be related to #13 - Materials, companionship and labor, as there are links to the number of people employed in fisheries or salmon-based ecotourism. In the case of the example of Mont St-Hilaire BR (Box 1), the activities of the Centre would be related to ES # 1, 4 and 7 - regulating ES, #14 - material NCP, and #15 and 16 - non-material. Considering the importance of the centre in terms of protection, it also supplies services for the rest of the BR. Only by having people who are involved directly or even indirectly in this priority sector would it be possible to define these components in this BR.

Box 2: Clayoquot Sound Biosphere Reserve case study

The Communities of the Clayoquot Sound UNESCO Biosphere Reserve Region desire to live sustainably in a healthy ecosystem, with a diversified economy and strong, vibrant and united cultures while embracing the Nuu-chah-nulth First Nations "living" philosophies of lisaak (Living respectfully), Qwa' aak qin teechmis (Life in the balance), and Hishuk ish ts'awalk (Everything is one and interconnected).

Salmon populations highlights:
The Chinook salmon (*Oncorhynchus tshawytscha*) is an indicator species of iconic significance for indigenous peoples and coastal communities throughout the Pacific Northwest. The steady decline of Chinook populations in the Southern region of British Columbia and Northern region of Washington is a strong signal that marine health issues exist at the ocean ecosystem level. However, the multitude of factors potentially contributing to Chinook population losses presents an enormous information challenge for prioritizing biodiversity protection and conservation action at the local community level (NOAA, 2016). In Clayoquot Sound, wild salmon populations have declined an average of 53% over the last 20 years (CSAS 2012). The effects of decades of unsustainable forestry practices in Clayoquot Sound in the 1960's, compounded by climate change impacts such as river washouts in estuarine salmon rearing habitat, are continuing to have negative impacts on salmon habitat and population health. For example, habitat assessment reports completed within the last two years identify the degradation of estuarine ecosystems within several Clayoquot Sound watersheds as a significant limiting factor for West Coast Vancouver Island Chinook salmon population recovery (Smith & Wright 2016, Smith *et al.* 2016, Abbott *et al.* 2017).

Healthy Communities and Collaborative Salmon Stewardship:
The core priority of healthy communities and salmon stewardship touches on all the aspects of our region that make people and communities thrive, and is grounded in research documenting the social determinants of health and belonging. Coinciding with the Truth and Reconciliation Commission of Canada holding its closing events in Ottawa, a group of Canada's philanthropic organizations prepared a Declaration of Action committing to ensuring that positive action on reconciliation will continue. The Clayoquot Biosphere Trust signed the Declaration in 2016, which provides a framework for weaving

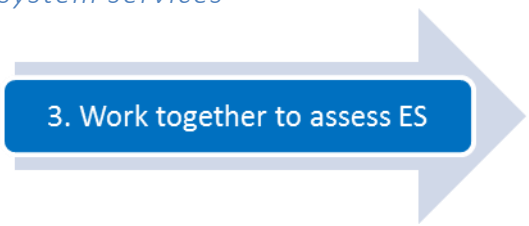
together the Clayoquot Biosphere Trust's actions and initiatives in the area of healing and reconciliation which are vital to community health and achieving the vision of the Clayoquot Sound Biosphere Region.

Clayoquot Salmon Roundtable:
Further to the goal of reconciliation, the conservation of wild salmon and their habitat is one of the highest priorities for community health and well-being in Clayoquot Sound. The Clayoquot Salmon Roundtable is a platform of 28 member organizations for building partnerships between traditional leadership, governments and stakeholders in a co-management process, based on consensus decision making, in order to develop the best possible plan for the recovery and sustainable management of Clayoquot Sound's wild salmon stocks. Key objectives of the Clayoquot Salmon Roundtable are:

a. Safeguard the genetic diversity of wild salmon populations;
b. Maintain salmon habitat and ecosystem integrity;
c. Manage salmon fisheries for sustainable benefits;
d. Recognize healthy salmon populations are interconnected with healthy communities, businesses and ecosystems (Hishuk Ish Tsawalk);
e. Acknowledge the importance of building relationships and capacity founded on Iisaak (Respect with Caring); and
f. Listen to active fishers, informed community members, traditional knowledge holders, and others who may have useful information about indicators.

For more information: http://clayoquotbiosphere.org/

4.3 Work together to assess ecosystem services



Assessment of ES can be simple or very complex. In this approach, we have tried to keep the process simple, although initially it may require more data collection. The first step would be to acquire data and information from the different partners about ES/NCP and make a summary of it to know what the initial situation is. This will require people to help each other and share information and knowledge and should be inclusive as possible in order to collect diverse information including local, ecological and traditional knowledge.

The first step is to invite as many people as possible to take part, including stakeholders with whom you normally interact and those that may not always be engaged in BR activities. There are many ways that participants can then work together. It can be in a formal meeting, a workshop or even someone's kitchen. Not all people are good at expressing with words. Visualization using maps or drawings can also help some participants express their points.

Convening people together to assess ecosystem services can be done in formal and informal settings

There are other more advanced techniques that can be used. For example, the Evaluation by Group Facilitation Method (EGFM) developed in 1986 by Université Laval (http://aruc.robvq.qc.ca/en/toolbox/fiches) is a tool that allows a group to define a common vision, and has been used for participatory activities such as climate change adaptation and ecosystem management strategy development.

Idea to Retain: Measuring the status of ES can be quantitative or as simple as using emoticons or a number scale to distinguish the degree of quality (from the lowest to the highest).

Or:

1 – 2 – 3 – 4 – 5

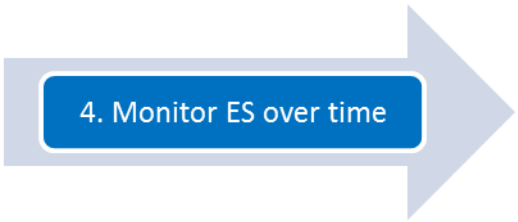
Using any of the methods briefly discussed above, participants working on these ES (e.g., salmon with ES #12 and #17) may discuss what they would consider their "health/status" to be. Based on the quality of the date you have, and the audience with which you want to communicate, you can then choose an appropriate scale to use. It is a good idea to remember to use consistent measuring as you reassess the ES over time. Relating the ES/NCP to the SDGs can help you link your BR work to local, regional and federal actions with regards to SDGs. To do so, the group would need to look at the specific objective or activity and discuss which SDGs it relates to.

This method has been used for sustainability indicators in the Niagara Region (http://www.livinginniagarareport.com/). They are assessed by categories such as environment, community belonging, health and wellness, by different groups of people with data, expertise or interest in the region. This approach is participatory and decisions on the status of an indicator are made by consensus in a meeting. For each ES, it is then possible to add narrative to complement existing data to better explain how ES were perceived by the community.

Examples of participatory processes:

- Benefit relevant indicators: Ecosystem services measures that link ecological and social outcomes: (https://www.sciencedirect.com/science/article/pii/S1470160X17307811)
- Non-monetary valuation using Multi-Criteria Decision Analysis: Using a strength-of-evidence approach to inform choices among alternatives: (https://www.sciencedirect.com/science/article/pii/S2212041617306344)
- Participatory identification and selection of ecosystem services: building on field experiences (https://www.ecologyandsociety.org/vol23/iss2/art27/)
- Civic ecology practices: Participatory approaches to generating and measuring ecosystem services in cities (https://www.sciencedirect.com/science/article/pii/S2212041613000880)
- Participatory scenario planning and climate change impacts, adaptation and vulnerability research in the Arctic (http://www.jamesford.ca/archives/5203)

4.4 Monitor ecosystem services over time



We believe that, by keeping this process simple it may be possible for BRs managers to assess ES on a regular basis, providing data to inform local decision making and to describe in the BR's periodic review. For example, a BR may decide to reassess one or two priorities/objectives every few years in a rotational basis while another BR may decide to monitor all of them every five years. Once the system is in place, BRs will be able to show trends in ES over time. This information will be valuable for assessing the impact of the BRs conservation and sustainable development activities, and for demonstrating the value of multi-stakeholder approaches to landscape management and planning.

Basically, what is important is that the process be transparent, inclusive, iterative and collaborative. This can help the people living in the BR to be more engaged and raise awareness of the ES/NCP that the BR is trying to promote, protect or restore with decision makers. It will also lead to further collaboration due to greater awareness and understanding of the importance of ES/NCP for local communities.

Conclusion

The aim of this paper was to help and guide BRs managers in Canada to find ways to assess ES in a simple manner that can be interactive, participatory and lead to greater collaboration with the various partners of the BRs. When an ES is declining, this approach can also lead to discussions, about the reasons why, and what solutions are possible to enhance its status. It may lead to new actions or decisions that would then become easier since the group would be having an increasing understanding of the BR ecosystem services as well as ongoing discussions about the related issues. The ES assessment conducted regularly (e.g. every 5 years) would also help manage sustainably some of the activities in BRs and in their various zones, and ultimately help the BR's management body make decisions on future actions based on the best knowledge available. We expect that most of this knowledge base would come from the ES assessment made in support to the BR period review report.

While we understand that this approach will still require baseline data collection and additional data would have to be examined on a regular basis, the focus for the BRs would be of higher relevancy as a function of the priorities / objectives instead of trying to inventory everything (which is not possible most of the time and data are usually limited). What will be important for BRs is to also recognize that not everything will be perfect on the first-time assessment and the approach may evolve and be refined over time. The proposed approach underlines the importance of using local resources and people as they are key to enhancing adaptive governance for ES conservation. Finally, it is also possible, and even desirable for group discussions to integrate ES into various other planning, conservation, and sustainable development efforts over time.

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(List of key documents and websites for people who want to learn more about ecosystem services, assessment tools, frameworks)

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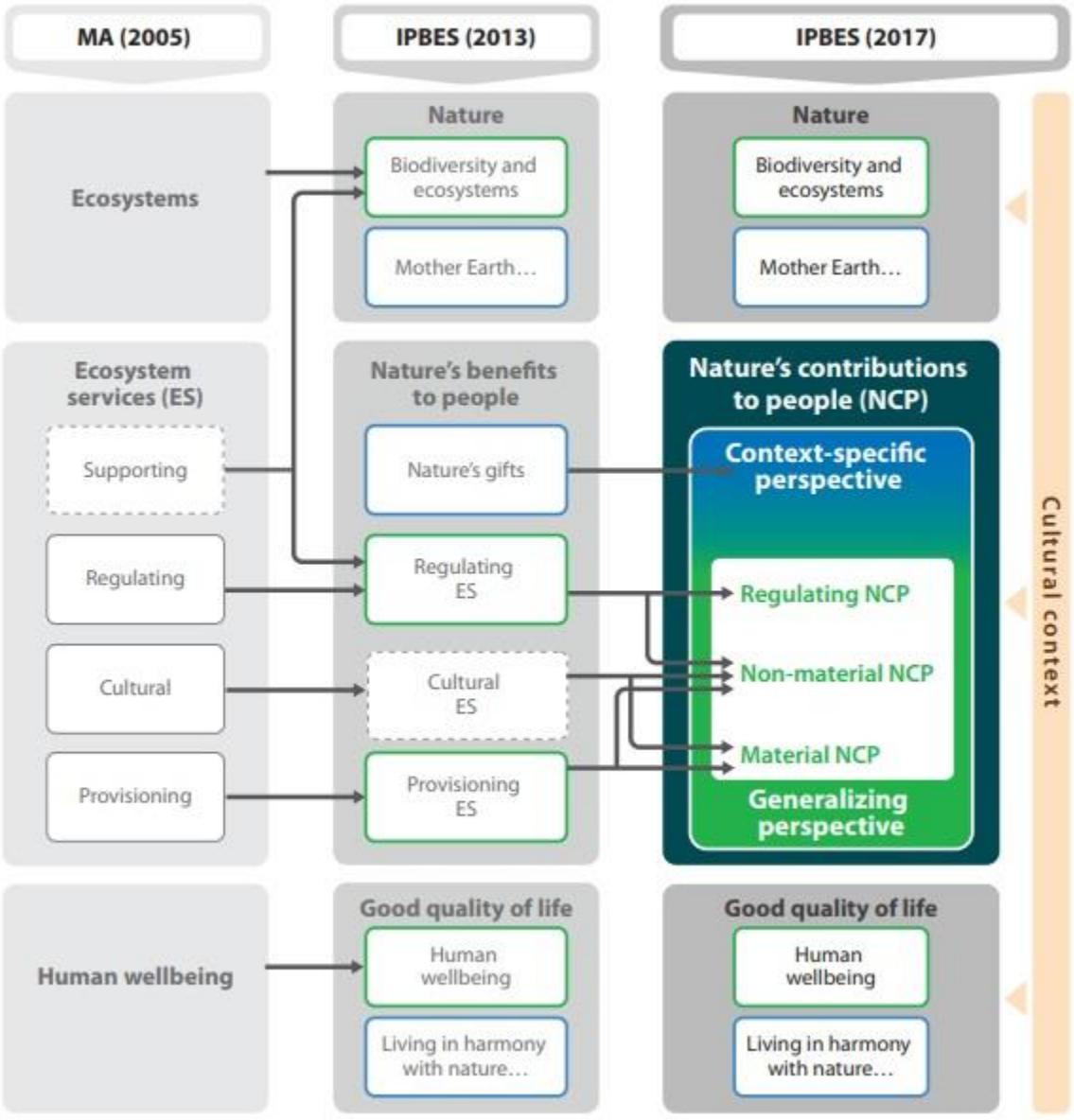
Appendix 1. Diaz *et al*. 2018 Supplemental:

(Reproduced with author permission, Diaz, S., Pascual, U. *et al.* (2018). Assessing nature's contributions to people. Science 359: 270-272).

Fig. S1. Evolution of nature's contributions to people (NCP) and other major categories in the IPBES conceptual framework with respect to the concepts of ecosystem services and human Well-being as defined in the Millennium Ecosystem Assessment. Categories in grey are part of the frameworks but not the main focus of this paper. The element "nature's benefit to people" was adopted by IPBES Second Plenary, and further developed into NCP by IPBES Fifth Plenary in order to fully capture the fact that the concept includes all contributions to people, both positive (benefits) and negative (detriments). Concepts pointed by arrow heads replace or include concepts near arrow tails. Concepts in dotted-line boxes are no longer used: following the present view of the MA community, supporting ecosystem services are now components of nature or (to a lesser extent) regulating NCP. Cultural ecosystem services were defined as a separate ecosystem service category in the MA; IPBES instead recognizes that culture mediates the relationship between people and all NCP.



Appendix 2. Questions asked in the self-study document

3. ECOSYSTEM SERVICES:

3.1 If possible, provide an update in the ecosystem services provided by each ecosystem of the biosphere reserve and the beneficiaries of these services. (As per previous report and with reference to the Millennium Ecosystem Assessment Framework and The Economics of Ecosystems and Biodiversity (TEEB) Framework (http://millenniumassessment.org/en/Framework.html and http://www.teebweb.org/publications/teeb-studyreports/foundations/).

3.2 Specify if there are any changes regarding the indicators of ecosystem services that are being used to evaluate the three functions (conservation, development and logistic) of the biosphere reserve. If yes, which ones and give details and update.

3.3 Update description on biodiversity involved in the provision of ecosystems services in the biosphere reserve (e.g. species or groups of species involved).

3.4 Specify whether any recent/updated ecosystem services assessment has been done for the biosphere reserve since its nomination/last report. If yes, please specify and indicate if and how this is being used in the management plan.

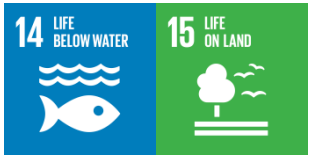
Reference: UNESCO, 2013. Periodic review for biosphere reserve.
http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/Periodic_review_form_english_2013.pdf

Appendix 3. Check-list for guiding the assessment of Nature's contributions to people (NCP) and Ecosystem services (ES) within UNESCO Biosphere Reserves during the periodic review process, and NCP/ES examples from the two case studies

ES Status can be quantitative or can use emoticons or a number scale

Or:

<1 – 2 – 3 – 4 – 5>

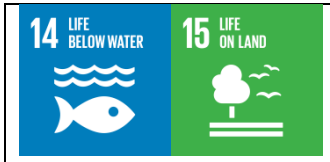
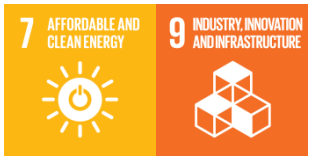
NCP categories and names and contributions[1] [2] to SDGs[3]	Main ecosystems producing NCP	Ecosystem Services examples [4]	Examples of related indicators	Biosphere Reserve case studies	
				Clayoquot Sound	*Mont-St-Hilaire*
Regulating NCP					
1. Habitat creation and maintenance 	All types of ecosystems	Essential habitat for species' life cycle (e.g., nursery, spawning ground areas, breeding areas, wintering grounds) including new habitat for species migration (i.e. climate change refugia)	Identification of habitat types Habitat quality assessment Status of coasts and river banks	Suitable habitat for salmon	Ha of forests and natural habitat Ha of protected areas Habitat quality (monitoring of species by citizen science) Habitat quality of aquatic ecosystems (based on both

[1] The Framework proposed by Diaz et al. (2018) and adopted by IPBES (2018 meeting) classifies NCP or Ecosystem services into three different groups (material, non-material, and regulating contributions) with emphasis on inputs from local and traditional knowledge and cultural ES.
[2] Note that certain ES and NCP can overlap and be found in two categories (e.g. #11 to 14), or even the three categories (#18) (Diaz *et al*. 2018)
[3] United Nations Agenda 2030 Sustainable Development Goals https://sustainabledevelopment.un.org/sdgs
[4] This list of examples is based on key references, which have proposed various frameworks to use the ES concept: The Millennium Ecosystem Assessment (MEA, 2005); The Economics of Ecosystems and Biodiversity (TEEB, 2010); Costanza et al. (2017); IPBES (2018) and Diaz *et al*. (2018).

					water chemistry and CABIN measures of aquatic insect abundance and diversity) Composition (amount) and configuration (placement, location, and shape, for example) of forest patches in the agricultural milieu.
2. Pollination and seed dispersal and propagules 	Forests, wetlands, agroecosystems	Essential process to plants reproduction and agriculture (crops)	Number and diversity of pollinators Plant populations pollinated		Number and diversity of pollinators in apple orchards Flower visits by pollinators Seed set in plants that require pollination (e.g., blueberries or apples)
3. Regulation of air quality 	Forests (incl., urban forests and parks)	Fighting urban Island effects during hot waves Air purification and pollution control	Measurements of air quality (CO2, O2, O3, sulphides, etc.) Surface of forests, parks, Differences in temperatures	n/a	n/a
4. Regulation of climate 	Oceans, wetlands and forests	Capture and store greenhouse gases at global scale Temperate local climate	Assessments of CO_2 emissions and other GHG when/where they exist	Above-ground carbon storage in forests patches in and around the reserve: estimation through surface area covered by forests	Above-ground carbon storage in forests patches in and around the reserve: estimation through surface area covered by forests
5. Regulation of ocean acidification	Oceans, coastal ecosystems	Buffer effect to reduce low pH impacts on	pH values in coastal waters,	Adequate pH values for salmon larvae and	n/a

		marine organisms (e.g. larvae and juveniles of fish, shellfish)	and trends over time	juveniles? See also water quality indicators	
6. Regulation of freshwater quantity, location and timing 	Rivers, lakes, streams, wetlands, watersheds, aquifers,	Drought prevention and recovery Flood attenuation (i.e. buffer zone for river flows)	Presence of wetlands, wetland surface and trends over time Presence of freedom space for rivers (yes/no)	Frequency of extreme hydro-climatic events (drought periods, floods, etc.) in BR zones	Wetland area Quality of riparian strips
7. Regulation of freshwater and coastal water quality 	Coastal areas, rivers and lakes, wetlands,	Water purification (i.e., natural filtration and oxygenation) Capture and retention of sediments and contaminants Biodegradation	Proxies for measuring water quality Presence of contaminants or nutrient sources Concentrations of contaminants, BOD/COD, nutrients, coliforms, etc.	Water quality in salmon rivers? Frequency of occurrences of algal blooms along the coast (disservices)	Quality of riparian strips Nb of restoration projects Nutrient storage in agricultural soils Capacity for additional nutrient storage in agricultural soils

			Status of coasts and river banks		
8. Formation, protection and decontamination of soil and sediments 	Coastal areas, rivers and lakes, wetlands, forests, agroecosystems	Nutrient recycling Accumulation of organic material for plant growth Maintaining soil fertility		Number of restoration projects	Nutrient storage (especially phosphorus) in agricultural soils around the reserve
9. Regulation of hazards and extreme events 	Coastal areas, wetlands, streams and rivers, lakes and reservoirs,	Extreme weather protection (e.g. storm, flood, drought) Soil and coastal erosion control (during intense runoffs or winds)	Monitoring the number of extreme events (per year, or decade) Assessment of damages and costs	Reduction of salmon habitats due to x storms in year?	Flood control (inverse of the # of flood events) Abundance of predators of aphids (aphids are a major soybean pest, and their predators are indication of natural aphid control)
10. Regulation of detrimental organisms and biological processes	All types of ecosystems	Primary production Biodegradation of organic matter Nutrient recycling	Regulation of pop. dynamics (e.g. predator/prey) Regulation of IAS, pests,	Presence of salmon prey in abundance? Salmon health status? Salmon diseases? Number of pests and invasive species that	Number of pests and invasive species that attack forests

			disease-vector species, etc. Number and types of diseases, pathogens, etc.	attack forests	
Material NCP					
11. Energy 	Agro-ecosystems, forests, marine/coastal ecosystems	Production of biomass-based fuels (e.g. biofuel crops, animal waste)	Quantity of energy produced Energy consumption	Amount of sustainable / renewable energy	Amount of sustainable / renewable energy
12. Food and feed 	Agro-ecosystems, aquatic ecosystems (fresh water and marine), forests	Fruits and vegetables, fish, crops, fodder, etc. collected by farming, hunting, fishing and aquaculture, harvesting and trapping, (incl., for subsistence)	Productivity Biomass Drinkable water produced or consumed	Quantity of salmon harvested, consumed, marketed?	Food or feed production
13. Materials, companionship and labor 	All types	Fibre, timber, lumber, etc. Freshwater for drinking (?)	Quantity of materials produced / consumed	Number of people employed in salmon fisheries? Number of Salmon fishers? Number of people employed in salmon-based ecotourism, i.e. recreational fishing?	n/a

14. Medicinal, biochemical and genetic resources 	All types	Medicinal and biochemical products from microbes, plants and animals	Production / use of natural medicines Assessment of genetic diversity Use of genomics measurements	Status of salmonids genetics?	Diversity of traditional plants Rare species identified
Non material NCP					
15. Learning and inspiration 	All types	Opportunities for the development of the capabilities that allow humans to prosper, through education, knowledge and skills Inspiration for art and technological design (e.g. biomimicry)	Tourism Recreational activities	Number of tourists coming for salmon fishing	Visitors to Mont Saint-Hilaire Biosphere Reserve recreational areas
16. Physical and psychological experiences 	All types	Opportunities for physically and psychologically beneficial activities, healing, relaxation, recreation, leisure, tourism and aesthetic	Physical and mental health indicators Indicators of well-being	Number of events organized in natural areas Aesthetic quality and viewsheds (do people perceive the beauty, cleanliness, etc. of BR areas?)	Aesthetic quality and viewsheds

		enjoyment based on the close contact with nature			
17. Supporting identities (spirituality) 	All types	Provision of the basis for religious, spiritual, and social-cohesion experiences	Cultural heritage Spiritual and religious values	First Nations events Number of traditional fishing areas protected	n/a
18. Maintenance of options 	All types	Capacity of ecosystems, habitats, species or genotypes to keep options open in order to support a good quality of life; i.e. ecosystem resilience and resistance in the face of environmental change and variability (e.g. for improving adaptation to climate change)	Number of restoration projects Number of clean up events or projects	Numbers of restoration projects in streams with salmon Number of creeks being protected from fishing	Rare species identified, and new populations located

		Ongoing biological evolution (eg adaptation to emergent diseases, resistance to antibiotics and control agents)			

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