Chapter 22
Ecosystem Services in Patagonia: A Synthesis and Future Directions

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Abstract In this closing chapter, we provide a synthesis of the Patagonian ecosystems and ES that were more frequently addressed in the preceding chapters, along with the main transformations and associated drivers. We also synthetize the research gaps and the recommendations provided by the authors and delineate future directions for ES research in Patagonia. Natural and human-induced drivers have modeled and remodeled Patagonian landscapes continuously. The chapters in this book describe recent landscape transformations and the major human-derived impacts on biodiversity and provision of ecosystem services (ES). The chapters also discuss implications of these changes for human well-being and provide recommendations for decision-making.

Keywords Patagonian landscapes · Terrestrial and marine ecosystems · Land-use change · Nature conservation · Human well-being

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1 Introduction

Fifteen years after the Millennium Ecosystem Assessment (MEA 2005), the concept of ecosystem services (ES) is widely recognized, both scientifically and politically (Bouwma et al. 2018). In parallel, the science related to the evaluation of ES and their contribution to human well-being has had an exponential expansion (Delgado and Marín 2015; Pauna et al. 2018; Perevochtchikova et al. 2019; Balvanera et al. 2020). Nonetheless, most ES research continues to focus on the biophysical quantification of ES flows or supply, over social dimensions (Lautenbach et al. 2019). The research carried out in the preceding chapters (Fig. 22.1) also reveals this trend.

To give continuity to the MEA, in 2012, 118 countries signed as members of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), including Argentina and Chile, with the mission of assessing the state of biodiversity and ES. IPBES presented its Regional Assessment Report on Biodiversity and Ecosystem Services for the Americas in 2018 (IPBES 2018) and its Global Assessment in 2019 (IPBES 2019), which confirmed the decreasing trend of biodiversity and ES reported by MEA in 2005. Among key messages, the America's IPBES Report stated that "many aspects of quality of life are improving at regional and sub-regional scales, but that the majority of countries are using nature more intensively than the global average and exceeding nature's ability to renew the contributions it makes to quality of life" (A4, p. 10). As a result, biodiversity and ecosystem conditions in many parts of the Americas are declining, resulting in a reduction in nature's contributions to people's quality of life.[1] Namely, "65% of nature's contributions to people in all units of analysis are declining, with 21% declining strongly" (B1, p. 12). In the case of Argentinean and Chilean Patagonia, the report documents an increase in the amount of temperate forests and woodlands habitat, but an increase in habitat degradation along with the decrease of native species diversity and the increase of alien and invasive species. The trends are similar for Patagonian grasslands and peatlands, but with a decrease in habitat amount.

Thus, the ES approach, despite its increasing popularity, has failed to reverse the loss of ecosystems' natural capital (Levrel et al. 2017) as neither have the approaches focused on the management of natural resources and the conservation of biological diversity (MEA 2005; IPBES 2019). The reasons for this outcome are diverse and

[1] Nature's contributions to people (NCP) are all the contributions, both positive and negative, of living nature (e.g., diversity of organisms, ecosystems, and their associated ecological and evolutionary processes) to the quality of life for people. Quality of life is understood in IPBES as the achievement of a fulfilled human life, a notion which may vary strongly across different societies and groups within societies. It is a context-dependent state of individuals and human groups, comprising aspects such as access to food, water, energy and livelihood security, health, good social relationships and equity, security, cultural identity, and freedom of choice and action. "Living in harmony with nature," "living-well in balance and harmony with Mother Earth," and "human well-being" are examples of different perspectives on a "good quality of life."

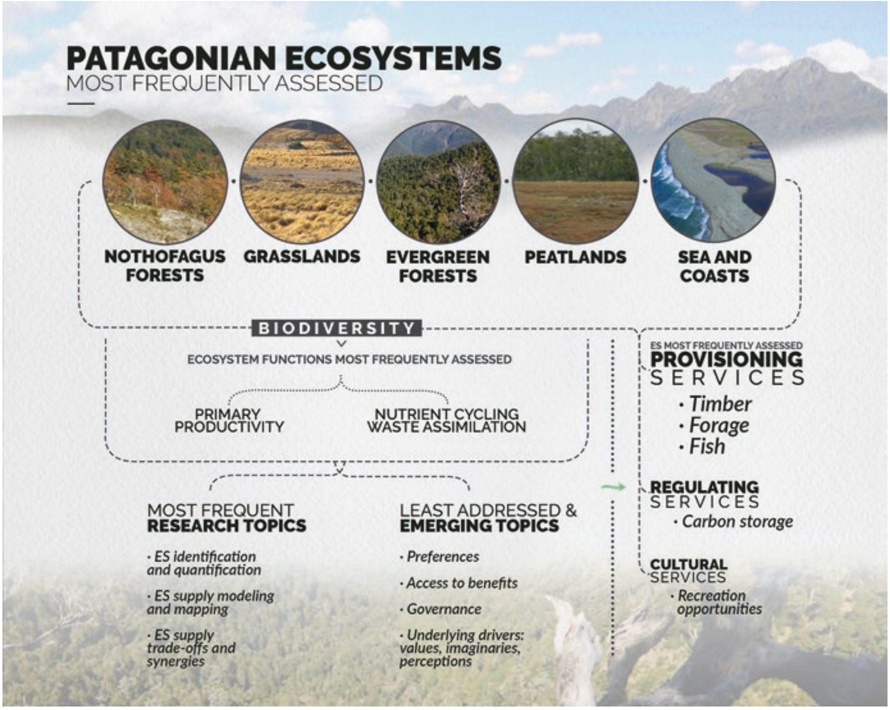

Fig. 22.1 Ecosystems, ecosystem services, and type of assessments covered in the book's chapters

range from structural ones, such as the capitalist production model, to operational ones, such as the gaps between ES science and decision-making.

Capitalism, as a political-economic system, depends on the expropriation and exploitation of natural resources and the environment, creating social inequalities and environmental degradation on an ever-increasing scale (O'Connor 1991; Moore 2017). This has been called the "second contradiction of capitalism" designated as "the absolute general law of environmental degradation under capitalism" (O'Connor 1991).

On the other hand, various studies have described and exemplified the causes of science-policy gaps in the field of ES (Saarikoski et al. 2018). Among them are (i) the rapid proliferation of definitions, conceptual frameworks, approaches, and evaluation models of ES within the scientific community, which has made it difficult to understand and implement the concept (Polasky et al. 2015), (ii) the complexity that the concept represents for decision-makers (Posner et al. 2016), and (iii) the different ontologies regarding nature and conservation (Dick et al. 2018).

The research in the precedent chapters shows significant advances in ES knowledge but also reveals the challenges we still have for bridging ES knowledge and decision-making. Additionally, the legal and institutional systems of Argentina and Chile do not always offer opportunities for the incorporation of the ES approach. As a result, in Patagonia there is still no effective incorporation of ES into public and private decision-making regarding nature conservation and natural resources management (Chap. 20).

This closing chapter provides a synthesis of the preceding ones using as a lens the conceptual framework presented in Chap. 1. We focus on the ecosystems and ES that were more frequently addressed in the preceding chapters, along with the main transformations and associated drivers. We also synthetize research gaps and recommendations made by the authors and delineate future directions for ES research in Patagonia.

2 State of Knowledge of the Ecosystems and Ecosystem Services of Patagonia

The research reported in the preceding chapters covers a great diversity of natural ecosystems. Most of the ecosystems studied were terrestrial, since they are the most relevant in terms of extension, with an important presence of studies in grasslands and deciduous forests of *Nothofagus* species, as well as mixed evergreen. In these ecosystems, the most studied ES were provisioning ES, specifically forage, livestock production, and wood (Fig. 22.1).

Aquatic ecosystems were less represented, particularly freshwater ecosystems. The most frequently addressed topics focused on the quantification and modeling of ecosystem functions and intermediate and final ES as well as the mapping of ES bundles (Chaps. 2, 3, 4, 5, 6, 7, 8, 10, 12, and 17). Additionally, some of these studies considered different trade-offs and synergies between biodiversity and ES such as fauna biodiversity and livestock production (Chap. 6) or gains in biodiversity from marine conservation vs. fair distribution of benefits across different social actors (Chap. 13) and between ES such as wood and water regulation, under pastoral and forest management scenarios (Chaps. 4 and 6). These studies included different scales of analysis from forest stands to provinces and larger territories, using a variety of spatial indicators and quantification and mapping techniques. On the contrary, issues associated with the demand side of ES, specifically the evaluation of benefits and beneficiaries, were less covered or superficially included. The exceptions were Chap. 15 that analyzed the supply and coproduction of marine ES and their distribution across direct and indirect beneficiaries and Chap. 16 that compared ES and benefits obtained from ES by rural households in two watersheds.

As emerging research topics that depart from traditional ES supply assessments, the following can be highlighted: (i) studies that analyzed individual preferences and contributions of ES to well-being (Chaps. 13 and 14) and social imaginaries of nature-human relations influencing stakeholder's decisions regarding the use of ecosystems (Chap. 19); (ii) distributive studies, which looked at the result of the interaction between social actors, institutions, and natural capital (Chaps. 15 and

18); (iii) studies that associated ES and long-term sustainability (Chaps. 9 and 11); and (iv) studies that looked at indirect benefits arising from ES (Chap. 21).

From the conceptual and methodological point of view, there are "blind spots" related to critical questions that characterize the "holistic ideal of ecosystem services research" (Lautenbach et al. 2019). Table 22.1 summarizes five criteria that help typify these blind spots, which largely coincide with the diagnosis presented in Chap. 20 for previous studies conducted in the Patagonian region. The first criterion is social-ecological validity, meaning that measurements, modeling and monitoring of ecosystem functions and the social dimension related to ES supply and demand are close to the phenomenon measured. For example, the capacity of a forest to regulate water flow is not closely represented by the change in stream or river flows. Likewise, the well-being obtained from forest firewood is not closely accounted for by the per capita consumption of firewood.

The chapters that measured, modeled or monitored ES still have the challenge to meet this first criterion. Most studies still use proxies and GIS-based models as opposed to process-based models and statistical models that are capable of capturing ES supply, demand, and interactions.

The second criterion is the analysis of trade-offs, which is a crucial step for identifying promising management options (e.g., White et al. 2012). In general, the chapters showed an increasing recognition of the importance of trade-offs, but when trade-offs were indeed assessed, the most frequent approach was the use of a simple map overlay to assess bundles of ES or trade-offs between them (e.g., Chap. 4). The assessments did not use optimization approaches, analysis of the trade-offs at different scenarios or management alternatives, or statistical analysis of survey data including trait-based analysis (e.g., Hevia et al. 2017).

The third criterion is the assessment of off-site effects, also called peri-couplings (ES flows between contiguous social-ecological systems) and tele-couplings (ES flows between distant social-ecological systems). From the perspective of regional

Table 22.1 Blind spots in ES research as reported in the book's chapters

Criteria	Blind spots
Socio-ecological validity of ecosystem data and models	Single or few ES are assessed Modeling approaches used do not account for feedbacks, nonlinear effects, or spatial and temporal variability Lack of integration between biophysical and social aspects of ES Use of proxies and models without interactions Disciplinary studies; little interdisciplinary research
Trade-offs analyses	Few ES are considered Policy scenarios are generally not considered Trade-offs are simple ES overlays
Recognition of off-site effects or tele-couplings	ES demand aspects are not included Data is limited
Involvement of stakeholders	Stakeholders are only partially engaged in research design
Relevance and usability of study results	Critical decision-making problems are not detected

and global sustainability, it is important that place-based ES assessments do not overlook effects on other social-ecological systems (Liu et al. 2013). Without consideration of such off-site effects, there is considerable risk for the spatial spillover rebound effect (Maestre Andres et al. 2012), meaning that policies intending to protect biodiversity or ES in one place can have negative impacts on biodiversity, ES, or well-being in another place. This topic was partially considered in only one chapter of the book (Chap. 15).

The fourth criterion is stakeholders' involvement, which can build stronger links between science, policy, and society and ensure that research addresses real-world needs (Menzel and Teng 2010). Despite this recognition, ES research in Patagonia seems to be mostly driven by researchers' own interests, which might explain the low level of stakeholder engagement. In chapters that did engage stakeholders, their participation was limited to identifying and prioritizing ES (Chaps. 13 and 14).

The last criterion is the relevance and usability of research results. Addressing single aspects of ES assessments improves our knowledge on specific aspects of the conceptual framework in Chap. 1. However, the ES research most relevant for decision-making is the integrated assessment of multiple ES supply and demand linked with societal needs (Verburg and Selnes 2014; Beaumont et al. 2017; Lautenbach et al. 2019). Decision-making that aims to overcome sectoral views (e.g., forest management; water management) by integrating the components and interactions of coupled social-ecological systems needs to pursue the integration of ES supply and demand. This is a common blind spot in most chapters that included ES quantification and mapping, with the exception of those that simultaneously tackled ES supply, demand, and/or policies (Chaps. 15 and 18). Cash et al. (2003) concluded that the effectiveness of scientific information in societal decision-making is related to three main characteristics: saliency (relevance to decision-making), legitimacy (fair and unbiased information production that also respects stakeholders' values), and credibility (scientific adequacy). Failure to achieve these criteria can at least partially explain why ES knowledge has not been sufficiently implemented in decision-making in Patagonia (Chap. 20).

There are several reasons for blind spots: (i) perceived importance of the ES categories only determined by researchers and/or stakeholders, (ii) different research background of study leaders, and (iii) financial, logistic, and scientific challenges to assess ES supply, demand, and interactions in the territory. The blind spots summarized in Table 22.1 apply to those studies that focused on measuring, mapping, and monitoring ES. However, the chapters in this book also made important conceptual contributions such as the role of social imaginaries in nature conservation and ES (Chap. 19) and distributive justice issues (Chaps. 13 and 18).

3 Drivers of Change in the Socio-ecological Systems of Patagonia

In both sides of Patagonia, Argentina and Chile, the ecosystem transformations reported in the chapters occurred mostly in private lands. In the case of marine ecosystems, the status of the marine space as a public good or a "common pool resource" resulted in much more complex social-ecological interactions and transformations such as those described in Chaps. 12, 13, and 15.

The direct driver most frequently described in terrestrial ecosystems was land-use change and, specifically, the loss and degradation of forests due to urban expansion or the extraction of firewood and timber and the degradation of grasslands by overgrazing (Chaps. 3, 7, and 9). Another direct driver of great effect on the ecosystems of Patagonia was the expansion of invasive species such as the beaver, nonnative tree species, and salmon, which produce several adverse impacts on the natural ecosystems, but, at the same time, can generate services that benefit specific groups of people. For example, beavers modify most of riparian natural forests but at the same time generate ponds that are used by livestock in some areas or generate earnings for local tourism (Chap. 10). The expansion of nonnative tree species such as *Pinus radiata* and *Eucalyptus* sp., mostly in the northern Chilean Patagonia and of murrayana pine (*P. contorta*), ponderosa pine (*P. ponderosa*), and Oregon pine (*Pseudotsuga menziesii*) in Northern Patagonia on the Argentine side (Sarasola et al. 2006), while sustaining the timber industry, has been reported to have a myriad of negative effects on biodiversity and ES (Franzese et al. 2017; Corley et al. 2018). These controversial trade-offs and synergies are difficult to reconcile and present serious challenges to decision-makers.

Among the indirect or underlying drivers, the chapters described sociopolitical and, to a lesser extent, cultural drivers (values, beliefs, norms, and perceptions shared by people). Indirect drivers encompass the forces influencing private and public decision-making such as stakeholders' imaginaries and levels of education and knowledge and governance modes (Fig. 22.2), among others. These factors in turn influence the institutional arrangements for ecosystem management, as well as property rights over ES.

Both MEA (2005) and IPBES (2018) have recognized "weak governance" among the underlying drivers of ecosystem change. In Argentina and Chile, ecosystems and biodiversity are managed mostly under centralized governance arrangements, which are not aligned with the paradigm shift that the ES approach entitles. Although there are environmental policies and instruments (see Chap. 20) that aim to reduce pressure on biodiversity and ES, they have often not been effectively coordinated to achieve their objectives. Furthermore, subordination of environment to economic policies results in trade-offs and inequities in distribution of benefits (IPBES 2018) that cannot be fixed or prevented under current nature governance approaches.

The chapters generally focused on one or few drivers, but we have yet to make progress in studying the synergistic effects of multiple drivers on landscape

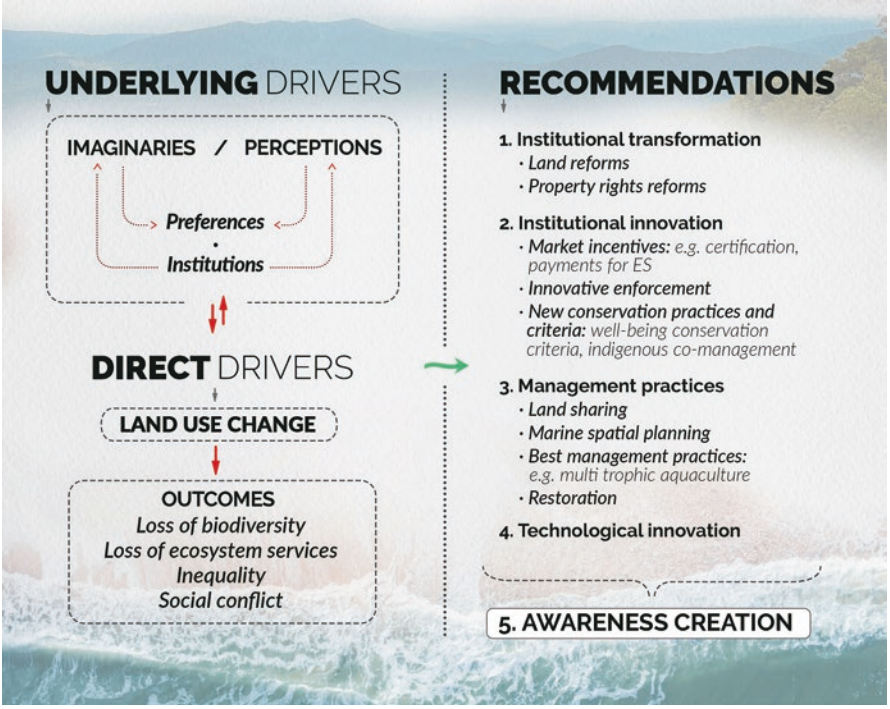

Fig. 22.2 Underlying and direct drivers of ecosystem change in Patagonia and recommendations in this book

transformations. When these transformations occurred on private lands, the trade-offs reported were usually those between provision ES and the other ES (Chap. 2). In these cases, private decisions largely responded to economic incentives (e.g., subsidies to agriculture or nonnative tree plantations) and were influenced by indirect external drivers, such as trade globalization. Specifically, while provisioning services have an exchange value in markets, regulating and cultural ES generally do not (with exception of carbon emission reductions and recreation opportunities); therefore private decisions do not take them into account. The exception to this rule occurs under other institutions such as private protected areas, whose objectives are not primarily economic (Chaps. 13 and 18).

Changes in ecosystems occur through the interaction between these multiple drivers, at different spatial and temporal scales. For instance, global trade (e.g., wood pulp, meat, salmon) places challenges to national, regional, and local governance, regulations, and management practices on ecosystems and their services, enhancing good practices but worsening the damage caused by poor practices. Increased trade can accelerate degradation of ES in commodity-exporting countries such as Argentina and Chile, if their policy, regulatory, and management systems are inadequate or weak.

Additionally, changes in ecosystems influence drivers in complex ways. For example, invasive species such as the beaver, which have led to the enormous destruction of forests in Tierra del Fuego, has been reimagined as an icon of regional identity, which creates conflicts when it comes to their management through authorized hunting. However, the benefits that this species could generate are well below the environmental and social costs it produces. Finally, altered ecosystems create new opportunities and constraints, induce institutional changes in response to degradation (e.g., restoration policies) and resource scarcity, and lead to social effects such as changes in employment.

4 Recommendations

The chapters provided recommendations to address direct and indirect drivers (Fig. 22.2), which are in line with those guidelines established in the IPBES assessments at both global and regional levels. IPBES guidelines include the implementation of specific public policies, behavioral change, improved technology, effective governance arrangements, education and awareness programs, scientific research, monitoring and evaluation, adequate finance arrangements, and supporting documentation and capacity-building. Specifically, the recommendations made in the chapters can be grouped into the following categories:

(i) Institutional transformation. An institutional transformation involves the change in the formal "rules of the game." This includes profound reforms to land ownership in the case of Chile, where very few owners own most of the lands and forests (Chap. 18). This inequality means that only large farms can sustain the provision of ES, consolidating distributive inequalities (Benra and Nahuelhual 2019). Along the same lines and in the case of marine ecosystems, a more equitable distribution of ES involves profound changes to access regimes and rights to marine resources (Chaps. 13 and 15), which in the case of Chile requires transformations to the Constitution, which are expected to occur in the coming years with a new constituent process. Deep social conflicts and efforts to secure purposive change are likely to demand strong civil society organization response if new imaginaries (Chap. 19) are to be discerned and effectively shared in ways that encourage sustained dialogue and the development of new social understandings (Stephenson 2011).

Materializing institutional changes does require not only marginal improvements to existing structures but also a modification of the actual objectives of environmental and development public policy, which implies incorporating new values, management visions, and new actors in a democratic and fair decision-making process. Doing so demands an approach that differs from the typically top-down, technocratic, and linear processes that characterize much of Argentina and Chile policy-making.

At a legal level, amendments are needed to overcome the current absence of an environmental code. It is also important to reorganize related environmental regulations, which in some cases contradict one another. This would also help solving the common problem of delays in the regulation of laws and their application in practice (Capaldo 2018) due to the dispersion of regulations. Likewise, efforts to harmonize legal and institutional frameworks should be undertaken in order to guarantee an effective protection of ES (Chap. 22).

(ii) Institutional innovation. Innovation often comprises technical processes and organizational changes in production and marketing, sometimes products, but rarely institutions. New formal or informal institutions emerge as responses to the shocks and stresses induced by market, social, and policy changes (Buttoud et al. 2011). For example, ES applications in the territory may incorporate innovation based on the creation, exchange, and application of new ideas into marketable goods and nonmarketable services, leading both to the success of an enterprise and the advancement of society (Boisvert et al. 2013).

Some chapters provide recommendations that involve institutional innovations. One example is the change in conservation criteria for marine protected areas (Chap. 13) as the result of increasing conflicts between local communities and public protected areas, whose creation obeys the command and control approach to governance. Traditionally, the creation and management of terrestrial and marine public protected areas has been guided by the protection of the so-called "objects of conservation", which are exclusively biological (e.g., endangered or iconic species or habitats). However, the new conservation standards for the achievement of the Sustainable Development Goals (SDG) require the inclusion of social criteria such as the recognition of livelihoods and the distribution of the benefits of conservation. The incorporation of "objects of well-being" in new conservation planning strategies (e.g., open standards for conservation) represents an opportunity to implement the ES approach in protected areas management through the identification of ES and key benefits for particular beneficiaries (Brain et al. 2020).

Another example is the reorientation of existing policies in order to improve the distribution of ES benefits. For example, the focus of regional tourism policies in Chilean Patagonia has been continuously placed on the generation of economic profits rather than on allowing local inhabitants to get to know their territory and natural beauties or on generating small-scale enterprises with local identity. Redirecting tourism and related economic policies toward local tourism markets can not only improve the distribution of benefits from ES but also increase local resilience in the face of events such as the coronavirus pandemic experienced during 2020–2021 (Chap. 15).

(iii) Management practices. The sustainable provision of ES to society is the main target of different ecosystem management approaches. In the precedent chapters, these management practices focus on two main areas: (i) the effect of specific practices on the provision of one or several ES and (ii) the interaction, trade-offs, and synergies between ES under different management scenarios.

These chapters mostly focused on provisioning ES, especially on timber obtained from deciduous *Nothofagus* forests and described the advantages of different silviculture alternatives (e.g., silvopastoral systems, firewood extraction schemes) (Chaps. 2, 4, 5, and 6). These management practices highlight the need of multipurpose objectives that promote several ES with broader social benefits. In addition, these proposals promote conservation within managed stands (land-sharing strategy) as opposed to those that only secure ES provision or biodiversity in natural reserve networks (land-sparing strategy). Sustainable management of forest stands is based on maintaining some legacies or natural values in the managed landscapes, which include not only monetary values (e.g., provision of timber or cattle) but also other ES (e.g., regulation, supporting, cultural) and biodiversity. Grasslands and shrublands were also analyzed in this book, where the equilibrium between the livestock and the natural ecosystem maintenance was the main challenge to face desertification, soil erosion, and the impacts of climate change (Chaps. 3 and 7). Management and conservation of peatlands were also described (Chap. 8). Finally, Chap. 9 proposed restoration practices to recover the losses of natural capital in the managed areas where sustainable management was not achieved.

The different chapters proposing management recommendations showed that under certain circumstances, it is possible to reach an equilibrium among social, ecological, and economic criteria in the management and conservation of the natural ecosystems in Patagonia. They also showed the importance of the private sector in elaborating these proposals (Chaps. 6, 8, 12, 14, and 15). The need for better policies to reach sustainable management of particular ecosystems was clear in the recommendations of the different chapters, which should aim at reducing some pressures to ecosystems (e.g., intensive salmon production; Chap. 12) or at promoting specific back-to-nature practices (e.g., retention forestry or harvesting based on gap creation; Chap. 4).

A pending task is the application of “adaptive management,” through theoretical and modeling approaches that can accommodate the complexities of real-world problems and embrace uncertainty through innovative experimentation and monitoring approaches (Keith et al. 2011).

(iv) Technology innovation. Modern nature conservation science operates at the frontier of technology. Innovative technology can enhance biodiversity conservation using a variety of technological options including big data, drones, artificial intelligence, and technological processes. Only one chapter formally proposed “eco-innovations” as one of the recommended solutions to the impacts of salmon farming on marine ecosystems (Chap. 12). At a global level, the salmon industry has made efforts to reduce the impacts by incorporating technology to mitigate environmental pressures, thus improving feed digestibility, food composition, and feeding technology. As a result, a reduction in nutrient excess, food waste, and deposition in sediments has been observed. A measure, not well explored yet in aquaculture in Patagonia, is the integrated multi-trophic aquaculture (IMTA). This proposal combines three trophic levels such as shellfish, finfish and but the scale of mariculture needed to mitigate pollution is sometimes unrealistic (Chap. 12).

Chapter 11 addressed forest restoration, which ranks very high among the options to recover impaired ecosystems. Whereas the chapter proposed important criteria for targeting forest restoration areas, a next step would be to assess implementation strategies, including benefits and costs of alternative options. Innovations in restoration usually rely on technological tools requiring high investments. However, there are also opportunities for making better use of the existing funds and for low-cost solutions (Brancalion and Van Melis 2017). Finally, technological solutions should take into account that ES coproduction in a given territory (e.g., spatial and temporal scales) is a complex multilayer process involving a variety of biophysical factors in interaction with a diversity of actors with different backgrounds, interests, and different spheres of influence.

Awareness creation and education. The ES has many strengths regarding awareness and education. In example, it increases awareness of the extent of human dependence on the environment, it promotes the integration between the natural and social sciences and helps acknowledging stakeholder knowledge, it helps understanding the impacts of environmental change and environmental policy on human well-being, and it contributes toward the achievement of sustainable society-ecosystems relationships (Bull et al. 2016).

The chapters in this book explicitly or implicitly support awareness creation and education for promoting nature conservation and management. Creating awareness implies making people more conscious of the benefits from nature and the relation between ES and well-being, including risk reduction. Making people aware of a greater number of ES may encourage them to design habitat management that better balances the provision of conflicting services (Richards et al. 2017). Awareness also concerns sustainability issues, which leads to changes in human consumption patterns and facilitates a transition toward less material- and energy-intensive activities. As stated in the IPBES America's Report, this implies, among others, a significant reduction in the consumption of meat and eggs as well as reduced wastage, which leads to less agricultural production and thus the reduction of the associated biodiversity loss.

Two chapters showed that people tend to recognize a large variety of ES and benefits derived from them (Chaps. 13 and 14). While provisioning services were more easily acknowledged, social actors also appreciated spiritual values. Awareness of regulating and supporting services, including those that were important for maintaining the stability and productivity of agroecosystems, was generally low.

Yet, it is important to recognize that there is still much distance between awareness and action. The high awareness-low priority dichotomy or also called behavior-impact gap (Csutora 2012) is principally due to the ineffectiveness of communication strategies. Some conventional awareness-raising approaches, such as fear creation, moralizing, and information provision, are insufficient in drawing positive behavior changes from the public on environmental issues (Chen 2016). In some cases, these approaches may create undesired effects, such as denial or anxiety. Therefore, alternative approaches are needed to close the gap, such as a deeper restructuring of the socioeconomic determinants of life (e.g., imaginaries covered in Chap. 19), including the culture of consumption (Csutora 2012).

5 From the Global Environmental Agenda to Local Research Directions

The international society expresses itself in norms, values, and institutions and in "anything that interferes with human activities beyond domestic jurisdiction" (Wight 1966). However, there is no single expression (either a norm or institution) that bears the title of "official" or "exclusive representative" of the international agenda (Martínez Reyes 2014). The international (global) agenda is a heterogeneous group of issues that are constantly discussed on the list of goals to be achieved.

An international agenda constitutes a "road map" where nations ultimately decide how to achieve a particular set of goals. In the case of the environment and sustainable development, these agendas are usually not legally binding, and therefore failure to comply does not imply sanctions, and the goals are generally renewed under new names. For example, the United Nations Millennium Development Goals (MDG) agenda (1990–2015) was not met and was replaced by the United Nations SDG agenda (2015–2030). The MDG environmental targets on which the world failed most roundly were "reversal of the loss of environmental resources" and a "reduction of biodiversity loss." Likewise, a decade ago, the world agreed to 20 biodiversity targets (Aichi Targets 2020) none of which was met by 2020.

Allegedly, the most integrative international agenda is the UN-SDG since it includes all issues relevant to the world and nations. The SDG are framed as a universal project, with substantial institutional monitoring mechanisms aimed at ensuring the successful implementation of aligned policies. Nonetheless, SDG have been criticized for being inconsistent, difficult to quantify, implement, and monitor. Some scholars suggest that there exists a potential inconsistency in the SDGs, particularly between the socioeconomic development and the environmental sustainability goals (Swain 2018). Other scholars show that the SDG agenda may be aimed in part at undermining political struggles that aspire for more socially just and ecologically sustainable approaches to development. Weber (2017) shows that the SDG framework is deeply aligned with the rules and regulations of key international development institutions, such as the World Trade Organization (WTO) and its highly contentious policies.

The SDG 13, 14, and 15 associated with climate action, life below water and life on land, have a strong link to biodiversity conservation and ES, in line with the Convention on Biological Diversity agenda and IPBES guidelines. The online information available for Argentina and Chile on SDG monitoring shows different levels of progress (https://dashboards.sdgindex.org/profiles). While Argentina reports moderate improvements for SDG 13, 14, and 15, Chile exhibits a decreasing trend in SDG 15 (Argentina shows stagnation). This reveals that Chile is failing to protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, reduce desertification, and reverse land degradation and biodiversity loss.

The achievement of the SDG implies a commitment by governments to change course and to leave "inertial" policies behind. Five years after the SDS adoption, both governments have failed to translate the proclaimed transformative vision of the 2030 Agenda into real policies. However, it is important to recognize that the implementation of the 2030 Agenda is not just a matter of better policies or science. The effectiveness of the political reforms requires holistic changes in power structures and depends on the existence of strong, democratic, and transparent public institutions at the regional, national, and international levels (Glass and Newig 2019).

Additionally, in 2020, the pandemic increased poverty and hunger, and revealed the weaknesses of health and education systems and global cooperation. The global recession caused by the COVID-19 response is alarming and has made researchers question whether the SDG are fit for the post-pandemic time.

The challenges and the low level of progress exhibited by Argentina and Chile in SDG 13, 14, and 15 (as well as other SDG) had been evidenced in the chapters of the book: (i) the change from land use to urban land, industrial plantations, and croplands continues to impair natural ecosystems, biodiversity, and ES, and (ii) the current management practices have a limited impact in reversing these trends as long as population and consumption continue to increase. The same is true in ocean ecosystems although uncertainties are even greater.

General directions to address sustainability have been proposed by several authors (see Franco et al. 2019) and include environmental education, increased participation of economic and noneconomic interest groups in proposing relevant policy actions, policy-making and implementation coherence, adaptive governance, and democratic institutions (Glass and Newing 2019). Most importantly, because of the complex human-environment interactions, most environmental challenges require fundamental changes in attitudes and behaviors from governments, industry, and individuals. While most people think sustainability is an important problem, they are often unresponsive, seem slow to act, do not always understand, and often deny environmental imperatives, creating substantial social and psychological barriers (Soron 2010).

Given the size of the task, the role of science (and technology) is obviously limited, for several reasons. Firstly, current mechanistic, reductionist science is inherently incapable of providing the complete and accurate information, which is required to successfully address environmental problems. Even under new research paradigms as sustainability sciences, there are fundamental bounds to our ability to design sustainable transformation pathways based on evidence. Human-environment systems remain highly complex and difficult, or impossible, to map fully. Causes and effects are often hard to distinguish and context dependent (Voulvoulis and Burgman 2019). Stakeholders frequently disagree about problems and solutions. In such cases, decision-makers must navigate ways forward based on careful consideration of risks, uncertainty, and issues of social justice. Precautionary measures or interventions may be advisable even if cause-and-effect relationships are not fully established. Secondly, both the conservation of mass principle and the second law of thermodynamics dictate that most remediation technologies, while successful in solving specific pollution problems, can cause inevitable negative environmental impacts elsewhere or in the future. Thirdly, it is intrinsically impossible for extractive (e.g., large-scale timber extraction or livestock operations) or industrial processes (e.g., industrial salmon farming) to have zero environmental impacts. Fourthly, most environmental problems and their solutions have more to do with political decisions (e.g., income distribution and poverty reduction policies with north-south cooperation) than with environmental science or technology innovation.

In this state of affairs, it is necessary to reflect on two linked questions: (i) how much more ES research is necessary to achieve sustainability in Patagonia and (ii) on which components of the conceptual framework proposed in Chap. 1. Chapter 20 and the present chapter make a contribution toward answering the second question by means of synthetizing research gaps. As to the first question, whichever the answer, we believe that a great effort is needed to share and systematize the existing ES knowledge. Thus, a true innovation might be research synthesis, which is still incipient in ES in Argentina and Chile. Research synthesis is the integration of existing knowledge and research findings pertinent to an issue, in order to increase the generality and applicability of those findings and to develop new knowledge through the process of integration. Synthesis is promoted as "an approach that deals with the challenge of information overload, delivering products that further our understanding of problems and distil relevant evidence for decision-making" (Wyborn et al. 2018). Yet, different ontological positions, epistemological positions, paradigms of inquiry, foundational theories, and philosophies and methodologies can make the synthesis a daunting initiative (Sandelowski et al. 2006).

Despite the challenges and faced with the urgency to meet sustainability targets, ES research needs to move to evidence syntheses or integration of research findings derived from systematic reviews of empirical research in targeted research areas to answer specific research questions addressing specific practice problems. Such evidence syntheses might truly have the potential to increase the utility of ES research and the effectiveness of practice.

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