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NOTE AND COMMENT

Restoring the human capacity for conserving biodiversity: a social–ecological approach

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Abstract Achieving biodiversity targets will require acknowledging that human societies are highly interconnected with the biophysical life-support system, conforming social–ecological systems. Under the social–ecological systems framework, we recognize that human wellbeing depends, in part, upon ecosystems; additionally, biodiversity conservation depends on human behavior and governance. Precisely, under the social–ecological systems paradigm, three conservation challenges emerge: (1) to recognize the value pluralism of biodiversity in science and decision-making, (2) to acknowledge that social–ecological systems require institutional diversity to be managed effectively, and (3) to go beyond scientific disciplines towards a real transdisciplinary science. In this context, sustainability science emerges as the body of knowledge able to understand the complex interactions of social-ecological systems. Consequently, we argue that the current challenge of biodiversity conservation needs to be addressed through the operationalization of sustainability science along the three lines above.

Keywords Ecosystem services · Institutions · Local ecological knowledge · Social–ecological systems · Sustainability science · Value-pluralism

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Introduction

The 2010 biodiversity targets and, now, the Decade on Biodiversity (2011–2020) declared by the United Nations have markedly stimulated international and national efforts toward biodiversity conservation in terms of policy and science as well as in terms of social awareness (Rands et al. 2010). However, biodiversity continues to decline despite these efforts (Butchart et al. 2010; Pereira et al. 2012; Tittensor et al. 2014). This situation can be partly explained because traditional Western-centric conservation approaches, i.e., legislation on endangered species and protected areas, although needed, are not sufficient to decrease the current rates of biodiversity loss. These traditional conservation approaches can disconnect ecosystems and society (Folke et al. 2011) for three major reasons.

First, many protected areas have been promoted by conservationists and scholars from natural sciences, who hold the belief that species, ecosystems and landscapes should be protected against human impacts. This process has entailed that people have been separated from their environment and, as a result, human access to specific provisioning services (e.g., non-timber forest resources, fishing, hunting) have been restricted and the use or enjoyment of specific cultural services (e.g., aesthetic values of landscapes, recreational activities, and the maintenance of local identity) have been limited (Palomo et al. 2014).

Second, protected areas and legislation are mostly focused on the effects of human action (i.e., habitat loss, climate change, invasive alien species, pollution, overexploitation) instead of the underlying causes of the problem (i.e., the political, economic, cultural, or technical drivers of change) (Santos-Martín et al. 2013). For instance, for dealing with land-use changes there has been a significant progress in conserving at least 17 per cent of terrestrial and inland water areas by creating protected areas; however, ecosystems continue to be fragmented and degraded (Secretariat of the Convention on Biological Diversity 2014) and other pressures still remain inside and outside protected areas, such as water and soil pollution or over-harvesting (Laurance et al. 2012; Leroux and Kerr 2012). Nonetheless, in spite of such evidence, the traditional Western-centric conservation strategies still overlook the real causes, such as the provision of perverse subsidies that damage biodiversity, population growth, social inequity and power asymmetries, global markets and the dominance of a value-system that increase total levels of consumption (Fischer et al. 2012; Palomo et al. 2014).

Last, Western-centric conservation strategies do not sufficiently integrate other knowledge systems (i.e., indigenous and local knowledge systems) (Gómez-Baggethun et al. 2010; Iniesta-Arandia et al. 2014) that can contribute with useful information and practices to the challenge of biodiversity conservation (Turnhout et al. 2012; Tengö et al. 2014). Previous studies have demonstrated that the limitation of traditional management practices (e.g., farming, livestock grazing, hunting, timber management, or non-timber forest products gathering) due to conservation policies has contributed to erode local ecological knowledge (Tuner and Turner 2008; Gómez-Baggethun et al. 2010; Carvalho and Frazão-Moreira 2011; Iniesta-Arandia et al. 2014), which, in turn, entails the erosion of biodiversity and the provision of multiple ecosystem services (Bugalho et al. 2011; Martín-López et al. 2012).

In this context, if we want to move beyond documenting biodiversity erosion, we should be aware that human societies are part of nature, and we should recognize the keystone pillar of sustainability, i.e., we cannot change the limits of the biosphere and the physics of nature, but we can change human social systems (Ehrlich et al. 2012). Acknowledging that human societies are highly interconnected with the biophysical life-support system leads us to work within the context of social–ecological systems (Ostrom 2009).

The study of social–ecological systems focuses on understanding the relationships existing between nature and society, analyzing either the contributions made by biodiversity to human wellbeing or the human actions that, through institutions, affect an ecosystem's integrity. Under the social–ecological systems framework, we recognize that human wellbeing depends, in part, upon ecosystems; additionally, the ecosystem and biodiversity conservation depends on human behavior and governance processes (Reyers et al. 2013). Under the social–ecological systems framework, we believe that three conservation challenges emerge: (1) to recognize the value pluralism of biodiversity and ecosystem services in science and decision-making, (2) to acknowledge that complex systems, such as social–ecological systems, require institutional diversity to be effectively managed, and (3) to go beyond scientific disciplines towards a real transdisciplinary science (Ban et al. 2013). Precisely, sustainability science aims to understand the complex interactions of social–ecological systems (Carpenter et al. 2009). In this sense, the main contribution of this paper is to show that current challenge of biodiversity conservation needs to be addressed through the operationalization of sustainability science, which entails the incorporation of connected (and relatively new) research fields, such as social–ecological systems, ecosystem services or institutional analysis, as well as the connection of diverse knowledge systems.

Furthermore, because conservation thinking is currently moving from safeguarding species and habitats toward an integrated perspective that recognizes the dynamics between people and nature (i.e., 'people and nature' frame) (Mace 2014), a close collaboration between the biodiversity conservation and sustainability science communities is needed for successfully achieving the Aichi targets. Therefore, this paper seeks to draw attention in both scientific communities (i.e., conservation and sustainability communities) to collaboratively identify relevant biodiversity conservation challenges and address them through co-producing interdisciplinary knowledge.

Recognizing the value pluralism of biodiversity: beyond the debate of intrinsic and instrumental values

Recognizing the contributions of nature to human wellbeing, i.e., ecosystem services (MA 2005), entails the acknowledgment of new arguments for preserving biodiversity, considering both intrinsic and instrumental values. Although the concept of intrinsic value (also called inherent value) recognizes that biodiversity has a value in itself (independent of its usefulness), the concept of instrumental value assumes that biodiversity is valuable only as a means to obtain human welfare, satisfaction, or happiness. This dichotomy of value has guided the conservation debate of modern Western societies in recent decades, moving away from biocentric ethics (which refer to the promotion of conservation based on the idea that all living beings possess intrinsic value) to anthropocentric arguments (which consider that biodiversity conservation should be supported because it is a means for achieving human wellbeing) (Pascual et al. 2010; Jax et al. 2013). However, these approaches are not opposed, and an important challenge for conservation strategies is to acknowledge that the two value systems are complementary (Armsworth et al. 2007; Reyers et al. 2012). In fact, if we consider that people's relationships with nature is innate to human evolutionary history, we can conclude that we have an innate necessity to connect with ecosystems and biodiversity for both ethical (i.e., intrinsic value) and utilitarian reasons (i.e., instrumental value) (Wilson 1984; Simaika and Samways 2010). However, this discourse of biodiversity and ecosystem services values can obscure other value-types such as those called eudaimonistic values (i.e., basic conditions for living a 'good life') and fundamental values (i.e., substantial conditions for life on earth, such as the human connection to the 'land') (Jax et al. 2013). In fact, the current antagonistic discourse of biodiversity and ecosystem services values based on intrinsic vs. instrumental arguments may thwart the value-pluralism acknowledgment. One the one hand, as most environmental decisions are performed on the basis of economic arguments that contemplate costs and benefits, the argument of intrinsic values can cause that biodiversity is excluded in decision-making because it is treated as having no value ('monetary' value) (Mace 2014). However, on the other hand, because the instrumental values discourse is currently skewed in the scientific literature towards monetary values of ecosystem services (Chan et al. 2012a; Nieto-Romero et al. 2014), the cost-benefit analysis has acquired a privileged position as a tool to guide environmental decision-making (Jax et al. 2013; Martín-López et al. 2014). This fact may cause that we enter into a perverse feedback loop where the environmental decision-making requests economic information for taking decisions and, therefore, ecosystem services literature continues to be biased towards monetary valuation, while ignoring other value-types. By ignoring the idea of value-pluralism, scientists, practitioners and policy-makers may cause that the myriad ways of understanding biodiversity and ecosystem services by multiple stakeholders may be excluded in decision-making and, therefore, we also neglect the value systems of those who benefit from biodiversity and are or may be affected by its use and management (Chan et al. 2012b; Jax et al. 2013). Furthermore, the way that humans relate to nature on the basis of these underlying value systems has important implications for biodiversity conservation because the socially embedded value systems influence the rules and norms that society applies to manage biodiversity (Brondizio et al. 2010).

Designing a governance system: the acknowledgement of institutional diversity

To acknowledge that biodiversity conservation depends upon those individual and collective actions molded and modeled by the current institutional system involves the need to understand the governance system. By governance, we mean the creation of the social and political processes by which people in societies decide, share information, and make actions (Folke et al. 2005). This governance system is mediated by institutions, i.e., the conventions, norms, or rules that formally or informally regulate the interactions between stakeholders and between those stakeholders and ecosystems (Vatn 2005). Because the governance system involves the diversity of ways in which humans interact with nature, the governance of social–ecological systems requires a greater variety of processes as the complexity of the system to be managed increases (Ostrom 1998). In fact, the process of governing social–ecological systems should entail institutional diversity, including different types of institutions: (1) informal institutions (i.e., traditions, customs, and beliefs), (2) formal rules (i.e., laws and formal agreements), and (3) market-based institutions (Gatzweiler 2005; Ostrom 2005).

Informal institutions have been shaped by their environment and have molded the environment for centuries through trial-and-error learning and learning-by-doing processes, but they also shape people's behaviors and belief systems over decades through knowledge sharing and collective action. Societies have collectively used this local ecological knowledge (also termed ecoliteracy, indigenous knowledge, or traditional ecological knowledge) to guide their actions toward ecosystems for decades or centuries (Berkes 2001). Local ecological knowledge is defined as a cumulative body of knowledge, practices and beliefs, evolving by adaptive processes and cultural transmitted through generations, about the relationships between living beings (including humans) with one another and with their environment (Berkes and Folke 1998; Gadgil et al. 1993). In many cases, informal institutions are self-enforced and self-monitored by individuals in local communities through the use of local knowledge or due to the cosmological and spiritual beliefs of individuals (Colding and Folke 2000). In fact, there are many ways in which local ecological knowledge interacts and relates with informal local institutions (e.g., Colding et al. 2003; Ghimire et al. 2005; Tëngo and Belfrage 2004). In contrast to informal institutions, formal institutions (both formal rules and markets) are rapidly implemented because they are usually shaped by political processes (Fischer et al. 2012). These formal institutions can influence (and aim to influence) human behavior and, thus, informal institutions.

All of these institutions (i.e., informal, formal rules and markets) are socially embedded and arise from a combination of different knowledge sources, distinct worldviews, and belief and value systems, which, in turn, have co-evolved with environmental conditions (Pretty 2011). In fact, the current governance system involves the diversity of human actions over ecosystems shaped by these three types of institutions, which have evolved throughout social–ecological history. For this reason, the governance of social–ecological systems should work in these three types of institutions at the same time, entailing a high level of coordination and cooperation between institutions and across spatial and temporal scales.

However, as Holling and Meffe (1996) have noted, current institutional actions pursue the control of ecosystems in the short-term by formal rules that aim to counteract the effect of direct pressures (i.e., land-use change, climate change, pollution). More recently, the biodiversity conservation strategy of Western societies has incorporated market-based strategies, such as carbon markets, payments for ecosystem services, habitat banking, or endangered species credits (TEEB 2011). Those management strategies that are based only on one governance level (i.e., formal legislation or markets) often fail to ensure the ecosystem's capacity to deliver a broad spectrum of ecosystem services and promote environmental conflicts (Gómez-Baggethun et al. 2013; Palomo et al. 2014).

Market-based strategies fit better for those ecosystem services under a private ownership regime, such as certain provisioning services (i.e., food from croplands); however, property rights are not well-defined for most ecosystem services, and thus markets fail (Kinzig et al. 2011). In addition, specific cases of market-based strategies, such as Payments for Ecosystem Services (PES) or Reducing Emissions from Deforestation and Forest Degradation (REDD +) schemes, can overlook social equity considerations (Corbera and Pascual 2012; Pascual et al. 2014). To counteract these failures, the management of many ecosystem services requires regulatory enforcement (Joppa 2012). In this sense, formal legal institutions have been promoted with the aim of protecting nature from the impact of humans (e.g., protected areas). However, there is evidence that this strategy also fails to interrupt the effect of drivers of change (Rands et al. 2010), maintain the delivery of ecosystem services (García-Llorente et al. 2012), or preserve local ecological knowledge (Gómez-Baggethun et al. 2010; Iniesta-Arandia et al. 2014).

As the concept of ecosystem services is stakeholder-driven (Menzel and Teng 2010), management should place more emphasis on the stakeholders' knowledge, beliefs and practices collectively developed over decades, i.e., informal institutions. In fact, there is evidence in specific rural communities that show how governance alternatives based on informal institutions can succeed where neither markets nor legal institutions exist (e.g., Agrawal 1996; Agrawal and Yadama 1997; Ostrom 1998). The basic conditions by which local communities can create and sustain informal institutions to collectively manage their natural resources, even in the face of market pressures or state policies, have been systematically identified in previous studies (Ostrom 1990; McKean 1992; Dietz et al. 2003). The basic principles for creating robust informal local institutions—i.e., analytical deliberation (engagement of interested stakeholders in discussions of rules), nesting (institutional arrangement should be redundant and nested at different organizational scales) and institutional variety (employment of mixtures of institution types)—have been well-established as a result of multiple empirical studies (Dietz et al. 2003).

Consequently, to govern social–ecological systems with the aim of ensuring the delivery of a diverse flow of ecosystem services, we should move beyond formal institutions toward the recognition of institutional diversity (i.e., informal, formal rules and markets) at different organizational scales (i.e., nesting), as well as we should involve the diversity of stakeholders in a well-structured dialogue about the rules (i.e., analytical deliberation) (Agrawal 2007; Ostrom 2005). Here, flexible participation in decision-making, which ensure that multiple stakeholders representing different institutions regularly interact, is central for enabling analytical deliberation and collaboration among multiple institutions (Stringer et al. 2006). In addition to this horizontal social learning (at local scale), a vertical learning (between local institutions and those at higher scales) is also required for stimulating a nested organization. Furthermore, monitoring and evaluating are clearly necessary steps, where strengths and weakness of the participatory process are reported in different stages. Precisely, participatory processes for enabling collaboration among institutions should not be understood as 'a snapshot' applicable in the same way along the whole process. In contrast, a flexible view of participation that entails adaptation in any stage of the process is needed (Stringer et al. 2006).

However, beyond the general three principles mentioned above (i.e., institutional diversity, nesting and analytical deliberation) and the promotion of flexible participation in decision-making, to give concrete governance recommendations is challenging because the high amount of different local rule combinations from which institutional arrangements can be implemented as well as the diversity of stakeholders. Therefore, the design of a governance system for conserving biodiversity and ecosystem services should not be understood as 'a recipe' applicable in any given context and, therefore, scientists should further advance knowledge on the basis of a deep reflection on place-based research.

Going beyond current disciplines' boundaries: the challenge of sustainability science

Recognizing that biodiversity conservation is about species and ecosystems as much as humans and society (Mascia et al. 2003) suggests an interesting change in the way we approach biodiversity conservation. Although conservation programs are the result of human decisions and actions and most ecosystems and biodiversity have been affected by human activities at a global scale, the distinction between the major disciplinary sciences, i.e., the natural and social sciences, is still in force (Lelé and Norgaard 2005).

In this context, there is a need to rethink biodiversity conservation within an interdisciplinary framework on the basis of social–ecological systems (Ban et al. 2013). Here, sustainability science, as field that aims to understand social–ecological systems (Carpenter et al. 2009), faces three different challenges: (1) to operationalize the marriage of natural and social sciences, (2) to become in a use-inspired science that focuses on real social–ecological problems, and (3) to connect different knowledge systems.

First, the approach based on social–ecological systems broadens the science of biodiversity conservation, moving beyond 'pristine' ecosystems and species to the analyses of interactions between human and natural systems. The relevant information needed to analyze social–ecological systems emerges from the marriage of natural and social sciences and, thus, is situated in the need for real collaboration between natural and social scientists. In such collaborative efforts, an open-minded attitude of scientists is required to go beyond the epistemological differences and cross the boundaries of 'pure research' to build an interdisciplinary science (Lelé and Norgaard 2005).

Second, sustainability science aims to understand the interactions between ecosystems and social systems with a focus on real problems (Kates 2011). In this sense, sustainability science is thought as neither 'basic' nor 'applied'; but as 'useable' and 'actionable' science (Clark 2007; Lindenfeld et al. 2014). In fact, sustainability science academic forums have recognized that science should be used to improve environmental decision-making and, in doing so, scientists should reframe how they can collaborate with other stakeholders in the different stages of knowledge generation (Kauffman 2009; Land et al. 2012; Shirk et al. 2012; Lindenfeld et al. 2014). If sustainability science aims to advance knowledge for solving environmental and biodiversity problems, we should remember that problems have been (and are being) socially created (Mascia et al. 2003). Consequently, biodiversity conservation problems can only be tackled when the knowledge-construction process integrates diverse (often conflicting) stakeholders' beliefs, values and perceptions and, therefore, when researchers recognize the necessity to converge scientists, decision-makers and local stakeholders' rationalities (Stringer et al. 2006; Lindenfeld et al. 2014). We should acknowledge that the era of experts is over and that community-based, interactive or participatory approaches are needed in science as a way of engaging people in knowledge-construction processes and empowering people in decision-making processes (see previous section). Although different participatory methods (e.g., citizen juries, collaborative mapping, participatory modelling; participatory future scenarios) are increasingly being suggested in biodiversity and ecosystem services literature (e.g., Chan et al. 2012b; Ban et al. 2013; Palomo et al. 2014); scientific efforts need to be oriented (beyond public communication and consultation) toward finding shared perspectives of stakeholders (Stringer et al. 2006).

Third, sustainability science should appreciate and integrate (i.e., not only respect) indigenous and local knowledge as a different source of information (Pretty 2011). Precisely, for making decisions about biodiversity, recent calls have highlighted the need to combine local ecological knowledge with conventional scientific knowledge (Fazey et al. 2006; Raymond et al. 2010; Turnhout et al. 2012; Tëngo et al. 2014), but rarely such calls are operationalized in real world (e.g., Moller et al. 2004; Salomon et al. 2007; Gómez-Baggethun et al. 2012). This outlook requires that scientists start to accept the diversity of ways of knowing embedded in different culture and belief systems. To consider the different ways of knowing entails recognizing both the diversity of stakeholders and the multiple modes by which they interact with nature, making visible their social needs and their underlying value systems. Once the multiple knowledge systems are recognized, it is required to collate and validate the information obtained from local knowledge and scientific knowledge (Sutherland et al. 2013). Once the information is validated, it should be combined in a transparent way where different stakeholder groups interact and dialogue in participatory processes that promote iterative learning. Such participatory processes should give stakeholders the confidence for communicating to co-design and co-produce the required information to support environmental decision-making. However, to produce knowledge through the dialogue of different stakeholder groups and through combining different knowledge-systems may be challenging and it will require learning through doing in each place or region. Indeed, a diversity of ways for structuring an integrated knowledge should be sought in accordance with the particular environmental and cultural condition as well as existing local knowledge (Komiyama and Takeuchi 2006).

If sustainability science aims to contribute to biodiversity conservation challenges, it should transcend disciplinary and interdisciplinary approaches towards transdisciplinary science, where cooperation among scientists, practitioners, policy-makers and local and indigenous communities is imperative. Although, the importance of such cooperation has previously acknowledged in sustainability science (e.g., Komiyama and Takeuchi 2006; Land et al. 2012; Lindenfeld et al. 2014) and in biodiversity conservation communities (e.g., Turnhout et al. 2012; Sutherland et al. 2013; Tĕngo et al. 2014), it has rarely operationalized. Nowadays, there is an opportunity to further explore mechanisms for integrating different knowledge-systems in the context of Future Earth (http://www.futureearth.info/) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES; http://www.ipbes.net/), as both international initiatives highlight the relevance of promoting knowledge-systems pluralism.

Concluding remarks

Biodiversity conservation, beyond the loss of biodiversity, is now facing the problems of homogenization of landscapes, loss of cultural diversity, loss of local ecological knowledge, simplification of institutions, and thus homogenization of minds and worldviews (Pretty 2011). To counteract these trends, we seek to highlight the role of local ecological knowledge and informal institutions in shaping multifunctional landscapes that ensure the delivery of a diverse flow of ecosystem services and the conservation of biodiversity (García-Llorente et al. 2012; Martín-López et al. 2012). From the perspective of coupled social–ecological systems, biodiversity conservation highlights that human wellbeing depends upon nature and that human actions also affect biodiversity. In fact, biodiversity conservation has moved away from a focus on species preservation and protected areas to a 'people and nature' framing (Mace 2014). The 'people and nature' framing implies (1) to take into account the multiple people's values of biodiversity in assessments and decision-making, (2) to acknowledge the crucial role of informal institutions on preserving biodiversity, and (3) to transcend disciplinary and interdisciplinary approaches towards transdisciplinary science. To face the aforementioned three challenges, we really need a close collaboration between the biodiversity conservation and sustainability science communities. The present article, in fact, intended to identify some of the conservation challenges where both scientific communities should jointly navigate in order to advance knowledge.

Furthermore, if current framing of conservation is the 'people and nature' thinking (Mace 2014), it cannot be only addressed through the collaboration among scientists from different disciplines, but must be opened to the voices, views and knowledge of non-academic stakeholders. Accordingly, the audience of the present article goes beyond the scientific community and includes practitioners, policy makers and local communities. Here, the IPBES offers an extraordinary opportunity for the sustainability science and conservation communities to collaborate with stakeholders who held other knowledge systems, such as the indigenous communities, in order to collate relevant information, inform decision-makers and stimulate active science-policy dialogues on conservation issues (Pe'er et al. 2013). In the IPBES context, scientists should build a knowledge base that embrace a wide variety of knowledge systems, including different scientific disciplines and experiential and local knowledge (Turnhout et al. 2012; Tĕngo et al. 2014). In fact, we should recognize that we can never protect biodiversity if we do not previously respect those human value and knowledge systems that genuinely connect with the biosphere.

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