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Learning for resilience? Exploring learning opportunities in biosphere reserves

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The interdependence of society and nature, the inherent complexity of social–ecological systems, and the global deterioration of ecosystem services provide the rationale for a growing body of literature focusing on social–ecological resilience – the capacity to cope with, adapt to and shape change – for sustainable development. Processes of learning-by-doing and multiple-loop social learning across knowledge systems and different levels of decision-making are envisioned to strengthen this capacity, combined in the concept of adaptive governance. This study explores how learning for resilience is stimulated in practice; investigating learning opportunities provided in UNESCO-designated biosphere reserves (BRs). A global survey (N = 148) and qualitative interviews with key informants of selected BRs (N = 10) reveal that a subset (79) of the BRs serve as 'potential learning sites' and: (1) provide platforms for mutual and collective learning through face-to-face interactions; (2) coordinate and support the generation of new social–ecological knowledge through research, monitoring and experimentation; and (3) frame information and education to local stewards, resource-based businesses, policy-makers, disadvantaged groups, students and the public. We identify three BRs that seem to combine, in practice, the theoretically parallel research areas of environmental education and adaptive governance. We conclude that BRs have the potential to provide insights on the practical dimension of nurturing learning for social–ecological resilience. However, for their full potential as learning sites for sustainability to be realized, both capacity and incentives for evaluation and communication of lessons learned need to be strengthened.

Keywords: learning; adaptive governance; sustainable development; biodiversity conservation; knowledge; environmental education

Introduction

In an increasingly complex world that is rapidly changing, individuals, organizations and societies need resilience – here defined as the capacity to cope with, adapt to and shape change. However, trying to build individual and social resilience, while eroding ecological resilience, is not a viable option. Every human being ultimately depends on the services that ecosystems provide, such as food production, nutrient recycling and flood buffering (Millennium Ecosystem Assessment 2005). The interdependence of society and nature, the inherent complexity of social–ecological systems (sensu

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Berkes and Folke 1998), and the rapid deterioration of ecosystem services across the globe provide the rationale for a growing body of literature focused on social–ecological resilience for sustainability[1] (e.g. Folke et al. 2002). A recent question raised by this literature is how the conventional, sector-based, top-down approaches to natural resource management and biodiversity conservation that are arguably ill-suited to the current situation can transform into adaptive governance for resilience in social–ecological systems (Folke et al. 2005). Adaptive governance is multi-level, learning-oriented and envisioned to enhance the fit between ecosystems and institutions, enabling ecological feedbacks (such as declining ecosystem services and loss of biodiversity) to be detected, interpreted and acted upon at the appropriate scale, thus enhancing people's capacity to handle inevitable changes, surprises and shocks – i.e. contributing to social–ecological resilience.

Knowledge and learning[2] are central concepts in the literature on social–ecological resilience and adaptive governance (Folke et al. 2002; Armitage, Marschke, and Plummer 2008; Berkes 2009; Lundholm and Plummer 2010). First, it is recognized that our activities are embedded in complex systems that are nested across scales, and that no single person can hold the full understanding of how to best approach problems. Combining different sources of information, and integrating knowledge from a diversity of mental models, then becomes critical to understanding and navigating social–ecological systems (Carpenter et al. 2009). Thus, the resilience approach emphasizes learning across sectors and scales. The importance of bridging scientific and experiential knowledge (i.e. local ecological knowledge, traditional knowledge and indigenous knowledge) has been particularly highlighted (see Berkes 2009 for a recent overview, and for an example, Shava et al. 2010). Second, the ever-changing nature of complex adaptive systems demands continuous reality-checks, where mental models, management practices and institutions are refined, adapted and transformed to better reflect system in which they are embedded. Individual managers as well as organizations and institutions need to be flexible and attentive enough to adapt to slow and rapid changes in a process of learning-by-doing. The type of place-based management that accommodates these learning processes has been coined 'adaptive co-management' (Gadgil et al. 2000; Olsson, Folke, and Berkes 2004; Armitage, Berkes, and Doubleday 2007). Adaptive co-management has also been described as the operationalization of adaptive governance (Folke et al. 2005).

Although continuous learning and extensive knowledge are deemed crucial in building and maintaining social–ecological resilience and fostering sustainable development, it is not possible for everyone to learn about everything, all the time. The resilience literature (see, e.g., Berkes and Folke 1998; Berkes, Colding, and Folke 2002; Folke 2006, and references therein) focuses attention on learning that takes place in natural resource management situations and, given the complexity of such situations, focuses on multiple-loop learning in social settings rather than knowledge transfer of known facts. Focus has mainly been on learning that improves *direct* management of ecosystems and natural resources, through changes in management practices as well as the institutions and mental models that frame ecosystem management. Learners in this literature have been ecosystem-related managers (Fazey, Fazey, and Fazey 2005) and local stewards such as farmers (Schultz, Folke, and Olsson 2007), as well as policy-makers at different levels (Dietz, Ostrom, and Stern 2003). Recent publications discuss the role of bridging organizations (Hahn et al. 2006) and networks (Crona and Bodin 2006; Davidson-Hunt 2006) in facilitating or hindering such learning.

The environmental (and sustainability) education literature on the other hand (e.g. Scott and Gough 2003, and references therein; Sauvé 2005 and references therein) has mainly focused on learning that changes the knowledge (e.g. Giordan and Souchon 1991, as cited in Sauvé 2005), values and attitudes (e.g. Pooley and O'Connor 2000) and behaviour (e.g. Hawthorne and Alabaster 1999) of people with a more *indirect* influence on ecosystems in their roles as consumers, voters and citizens. Learners in this literature are students in compulsory education as well as higher education.

The resilience literature and the recent environmental education literature share an emphasis on the importance of enabling learning that goes deeper than simply 'correcting errors in routines' (see also Sterling 2010). Traditionally, environmental education has assumed and emphasized that humanity's fundamental problems are environmental, and that learning about the environment will lead to behavioural change once facts have been established and communicated (Type 1 learning, Scott and Gough 2003). However, within the last 10 years there has been a growing recognition that this is a simplified view and critique has been raised against this linear assumption of knowledge leading to action (e.g. Kollmuss and Agyeman 2002). Problems concerning the environment can also be seen as political and social, and learning then becomes a tool to facilitate choice between alternative futures which can be specified on the basis of what is known at the present (Type 2 learning, Scott and Gough 2003). More recent approaches (Type 3 learning, Scott and Gough 2003) assume that desired 'end-states' cannot be specified, because present knowledge is not and cannot be adequate. In this context, learning must be open-ended and focused on critical thinking. Similarly, resilience literature emphasizes the need for multiple-loop social learning (Lee 1993; Armitage, Marschke, and Plummer 2008; Löf 2010) that not only corrects errors in current routines and practices but also questions the routines themselves, and the conceptions and worldviews shaping those routines. A revised view of the above learning types (1, 2 and 3), presenting them as being complementary rather than dichotomies, is given by Vare and Scott (2007). They emphasize that some facts are indeed agreed and some problems and solutions are identified, and then environmental education aiming at specific behavioural changes is needed (Education for Sustainable Development 1 [ESD 1]); yet at the same time, the future is unknown, and therefore environmental education that stimulates critical thinking and reflection and sustains open-ended learning outcomes is needed as well (ESD 2). Similarly, Steyaert and Jiggins (2007) call for a more effective balance between conventional approaches to natural resource governance such as raising environmental awareness on the one hand and social learning approaches on the other.

Bearing in mind the potential complementarity between the literatures discussed above, this paper examines how practitioners who aim to stimulate learning for sustainable development make use of various approaches, and target various groups in this endeavour. Our overarching question regards how learning that contributes to social–ecological resilience can be stimulated in practice. What learning processes and what groups are considered important? And what are the challenges involved?

To explore these questions, we have focused on a unique network of 531 biosphere reserves (BRs) in 105 countries that have the stated mission to act as 'learning sites' (UNESCO 2008, 8) where activities of biodiversity conservation, sustainable development, research, monitoring and education are to be prioritized, coordinated and demonstrated.

Biosphere reserves as learning sites

The 531 sites are designated BRs, internationally recognized by UNESCO under the Man and the Biosphere (MAB) programme. The programme was launched in 1970 as a long-term intergovernmental and interdisciplinary effort to reconcile biodiversity conservation and sustainable use, and the first BRs were designated in 1976 to serve as 'sites of excellence' and 'living laboratories' where experimental approaches to this endeavour could be tested (UNESCO 1996, http://www.unesco.org). These early sites were designated mainly on the basis of their high biodiversity values, and their links to ongoing research, but over time the emphasis on sustainable development, education and local participation has increased (Ishwaran, Persic, and Tri 2008). Since 1995, all BRs are expected to fulfil three functions, stated in the Statutory Framework (UNESCO 1996): conserving biodiversity; fostering sustainable development; and supporting research, monitoring and education. All BRs contain one or more protected areas, but what is unique in the BR concept is that it extends beyond protected 'core areas' to include the buffer zone and the transition zone (Figure 1). These buffer and transition areas encompass 80% of the areas covered by BRs, and this is where economic and social development compatible with conservation goals is envisioned to be stimulated (Ishwaran, Persic, and Tri 2008). The core areas are legally protected and surrounded by buffer zones where economic activities compatible with conservation are stimulated, such as tourism and organic agriculture. The transition zone can encompass cities and other human-dominated types of land-use and serve as laboratories for sustainable development.

At first sight, the World Network of Biosphere Reserves seems to represent an untapped resource of practical experiences taking place in different ecological, social and economic contexts on learning for sustainable development. First, the coupled functions of 'in-situ conservation of biological and cultural diversity' and sustainable development (UNESCO 1996, 16), and the mission to 'secure ecosystem services for human well-being' (UNESCO 2008, 8) suggest a holistic approach similar to that of

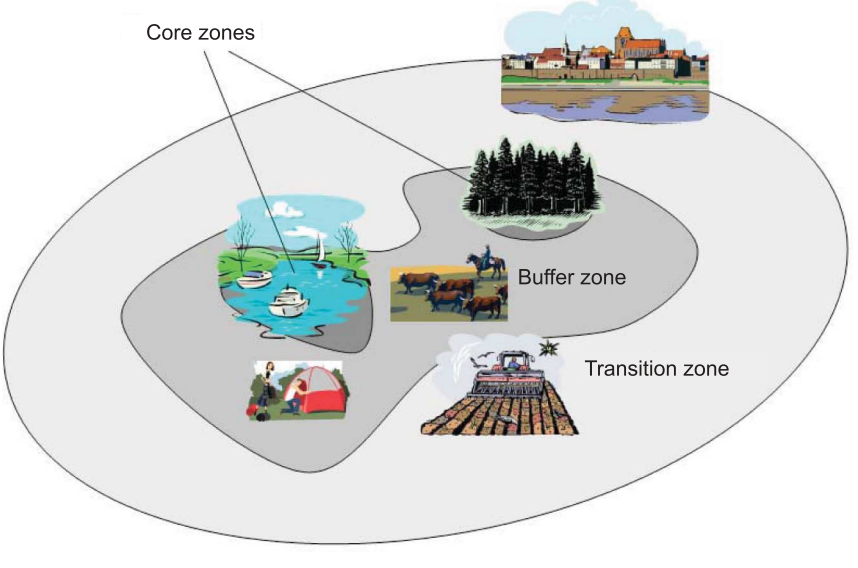

Figure 1. Stylized image of the biosphere reserve zonation.

social–ecological systems (sensu Berkes and Folke 1998, 4). Second, the function of providing 'logistic support for demonstration projects, environmental education and training, research and monitoring related to local, regional, national and global issues of conservation and sustainable development' (UNESCO 1996, 16) indicates a focus on learning processes that enhance understanding and management of the social–ecological system in focus (UNESCO 2000). Third, the criterion that 'organizational arrangements are provided for the involvement and participation of a suitable range of inter alia public authorities, local communities and private interests in the design and carrying out of the functions of a BR' (UNESCO 1996, 17) echoes the ideas of strategic collaboration and learning across sectors and scales suggested by the adaptive co-management approach (Olsson, Folke, and Berkes 2004; Armitage, Berkes, and Doubleday 2007). These similarities indicate that BRs provide a useful basis for empirical studies on the topic of learning in relation to sustainable development and building resilience. However, because policy and international frameworks are not always reflected in practice, the first step of this study was to assess to what extent the mission and recommendations of the MAB programme correspond to activities on the ground.

Most BRs have a place-based body that coordinates the activities related to the BR functions, and in this study we call these bodies biosphere reserve centres (BRCs) in line with Stoll-Kleemann and Welp (2008), who present a parallel global survey of BRs, conducted in 2006–2007. BRCs can be everything from a single coordinator working with the BR concept in a loosely defined network to a physical space with researchers, managers and information personnel. This study targets key informants from these BRCs, investigating: (1) to what extent the BRs act as potential learning sites for social–ecological resilience, defined here as sites where the BRC is working with supporting research, monitoring or education and with facilitating dialogue between practitioners and scientists; (2) what types of learning processes (if any) are prioritized by BRCs; and (3) what roles the centres play in facilitating these. The study is a first assessment of the current practices in BRs as seen from the perspective of BRCs and lays the ground for follow-up studies. Rather than giving any definite recommendations, it aims to highlight the potential of BRs as on-the-ground test sites for the various ways that environmental education and learning through adaptive governance can be combined to achieve effective learning for sustainable development and resilience, and suggests future research that could be useful in these areas.

Methods

Global survey

In order to get comparative information from a large number of BRs in the world network and to identify potential learning sites for follow-up studies, a self-administered, written questionnaire was developed (Kasunik 2005). The survey team was multi-disciplinary, including researchers with backgrounds in systems ecology, political science, rural studies and educational science. One of us had previous experience of BRs through a case study in Kristianstads Vattenrike BR (Schultz, Folke, and Olsson 2007; Hahn et al. 2008). Survey questions included: priority of each of the stated BR objectives (ranking), self-evaluated effectiveness in reaching each of these objectives (ranking), and degree of involvement of stakeholders in decision-making and implementation of BR processes (multiple-choice questions). There was a specific

question about whether the BRC had facilitated face-to-face activities in the BR, and a multiple-choice follow-up question on who had shared knowledge, and who had learned from such activities. The complete questionnaire can be accessed on request from the first author.

The questionnaire was tested, revised, translated and uploaded for online access via www.surveymonkey.com in English, French, Spanish and Chinese. An introductory letter with a link to the survey was sent via e-mail to the 407 BRCs for which we could identify functioning e-mail addresses. Hard copies were distributed at the 3rd World Congress of Biosphere Reserves held in Madrid in February 2008. The online survey was open from January 15 to June 20 and reminders were sent out twice during this period.

In all, 148 BRs from 55 countries were represented in the survey responses, a response rate of 28% (148/531). Although this response rate is rather low, it is reasonable in comparison with other global surveys of BRs. The telephone survey presented in Stoll-Kleemann and Welp (2008) achieved a response rate of 40%, and UNESCO (2001) reports a response rate of 29%.

Comparing the geographic distribution of the 148 responding BRs to the geographic distribution of the total network of 531 designated BRs, the responding BRs are fairly representative (Figure 2). The proportion of BRs designated before and after the adoption of the Statutory Framework in 1995 is also representative: 43% of the responding BRs were designated after 1995 as compared to 40% of the total network of BRs. However, high-income countries (as defined by the World Bank 2008) were over-represented in the dataset, amounting to 45% of the responses, as compared to 36% in the total network.

Based on the survey responses, the BRs were classified as potential learning sites if they fulfilled the following criteria:

(1) gave at least medium priority (ranking 5 on a 10-graded scale) to one or several of the objectives related to supporting education, supporting monitoring, supporting research, and facilitating dialogue and collaboration;

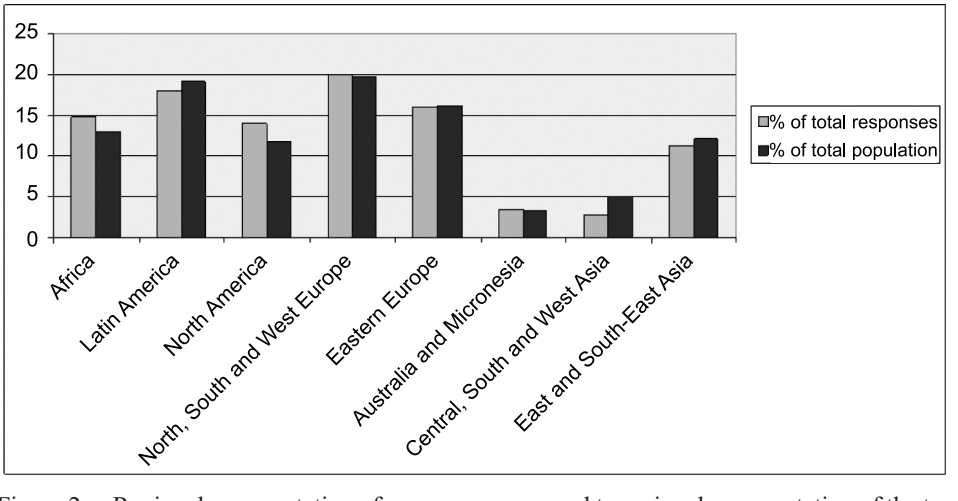

Figure 2. Regional representation of responses compared to regional representation of the total number of biosphere reserves in the world network.

(2) considered their effectiveness in fulfilling one or several of these objectives to be at least acceptable (ranking 5 on a 10-graded scale); and
(3) provided opportunities for local inhabitants or practitioners such as farmers and scientists to meet face to face (through participation in an advisory board or in face-to-face activities arranged by the BRC).

Seventy-nine of the sites fulfilled the criteria.

Qualitative interviews

In order to gain in-depth information on how BRCs in potential learning sites (as defined above) work to facilitate learning, we made follow-up telephone interviews using the interview guide approach (Patton 2002) with key informants from 10 BRCs, drawn randomly from the English-speaking part of this group (Table 1).

Interview questions were sent in advance to respondents and the interviews were conducted during January 2009, each lasting between 30 minutes and one hour. All interviews started with an open-ended question about how the Statutory Framework idea of learning sites was interpreted and realized. The following topics were then probed: support given to research, monitoring, experimentation and adaptive management; environmental education in the BR, including priorities, rationale, topics, means and target groups; and activities of face-to-face interactions between stakeholders with different knowledge. For the last question, all respondents were asked to describe in detail one such activity, including purpose, set-up, participants, results and lessons learned. The interviews ended with an open-ended question on what kind of support that the respondent would like from the MAB programme to enhance learning.

The interviews were transcribed and then analysed manually and independently by the two authors. Six types of learning opportunities created by BRCs emerged from the responses after open and then selective coding. One cycle of iteration was done through member checking (Lincoln and Guba 1985): We e-mailed all 10 respondents individually with a list of these six learning opportunities and the examples we had found from their respective interview and survey response, asking each respondent to complement and correct our interpretation. For the sake of clarification, the six types

Table 1. Biosphere reserves represented in interviews.

Biosphere reserve	Designation year	Size (hectares)
Cape Winelands (South Africa)	2007	322,030
Channel Islands (United States)	1976	479,652
Delta del Orinoco (Venezuela)	1993	8,266,230
Frontenac Arch (Canada)	2002	150,000
Krivoklátsko (Czech Republic)	1977	62,881
Lower Morava (Czech Republic)	1986 extended 2003	24,240
São Paulo City Green Belt (Brazil)	1993	1,611,710
Niagara Escarpment (Canada)	1990	190,270
Schorfheide-Chorin (Germany)	1990	129,161
Wienerwald (Austria)	2005	105,645

of learning opportunities were then sorted into three approaches to learning taken by BRCs, and six categories of groups involved (Table 2).

Results

Descriptive statistics of survey responses

Seventy-nine of the 148 BRs fulfilled the potential learning site criteria (53%). The proportion of high- and non-high-income countries among these BRs was similar to the whole sample, and so was the proportion of pre-Seville and post-Seville BRs. However, the average self-evaluated effectiveness of potential learning sites was higher in all objectives (Figure 3). Furthermore, they perceived a higher support from people living in the BR.

Qualitative interviews

The qualitative analysis of the interview transcripts revealed three approaches to learning that BRCs take in their ambition to foster sustainable development and in-situ conservation of biodiversity (Table 2, Figure 4). In total, the learning opportunities created by these approaches involve six target groups. Three of the BRCs have a particularly broad scope; they provide learning opportunities using all three approaches and target two or more groups in each (*Schorfheide-Chorin*, *Wienerwald* and *Channel Islands*, see Table 3). We will deal with each approach separately, providing thick

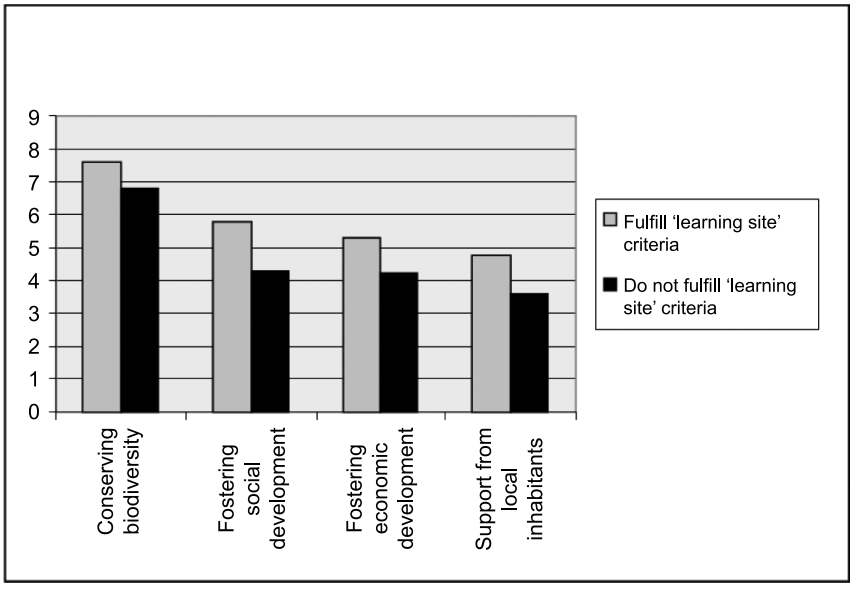

Figure 3. Self-evaluated effectiveness and perceived local support of potential learning sites compared to the rest of the responding biosphere reserves. Note: Comparison of arithmetic means. *t*-test shows that the difference is significant for conserving biodiversity ($p = 0.024$), fostering economic development ($p = 0.000$), fostering social development ($p = 0.013$) and local support ($p = 0.002$). 1 = very poor, 5 = acceptable, 9 = very good. On the question about support from local inhabitants, 1 = totally insufficient, 5 = sufficient and 9 = more than sufficient.

Table 2. Types of learning approaches and target groups involved ($N = 10$).

Target groups	Enabling mutual and collective learning	Building and updating a body of knowledge	Framing information and education
Scientists	5	8	0
Local stewards and resource-based businesses	8	2	8
Policy-makers at different levels and sectors	7	0	6
Disadvantaged groups	1	0	3
Students	0	1	7
Citizens and consumers in general	4	3	6

Note: Figures represent the number of BRCs reporting in the interviews to be engaged in the respective activity.

Table 3. Learning priorities of interviewed BRCs: approaches and groups involved ($N = 10$).

Biosphere reserve	Enabling mutual and collective learning	Building and updating knowledge	Framing info and education
Cape Winelands (South Africa)	Policy-makers from different levels and sectors		Local stewards, policy-makers, disadvantaged groups, students
Channel Islands (United States)	Scientists, local stewards, policy-makers	Scientists, citizens/consumers	Local stewards, students, citizens/consumers
Delta del Orinoco (Venezuela)	Scientists, local stewards, policy-makers, citizens/consumers, disadvantaged groups	Scientists	Local stewards, disadvantaged groups
Frontenac Arch (Canada)	Local stewards	Scientists	Local stewards, policy-makers, students, citizens/consumers
Krivoklátsko (Czech Republic)	Policy-makers, citizens/consumers	Scientists	Students
Lower Morava (Czech Republic)	Local stewards, policy-makers, citizens/consumers	Scientists	Local stewards, policy-makers, citizens/consumers
São Paulo City Green Belt (Brazil)	Scientists, local stewards, policy-makers	Scientists	Disadvantaged groups
Niagara Escarpment (Canada)	Scientists, local stewards	Citizens/consumers	Local stewards, policy-makers, students, citizens/consumers
Schorfheide-Chorin (Germany)	Local stewards, policy-makers, citizens/consumers	Scientists, local stewards, students	Local stewards, policy-makers, students, citizens/consumers
Wienerwald (Austria)	Scientists, local stewards	Scientists, local stewards, citizens/consumers	Local stewards, policy-makers, students, citizens/consumers

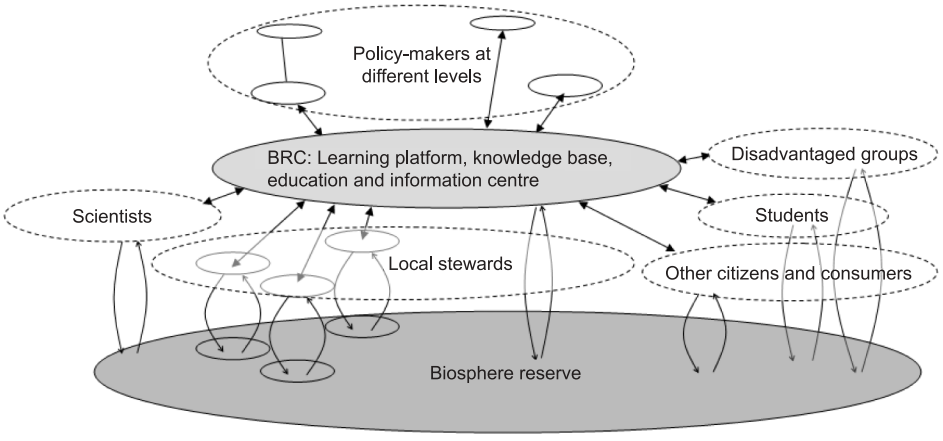

Figure 4. Biosphere reserve centres interviewed provide learning opportunities in three different ways and target six different groups.

descriptions of examples. BR names are used as pseudonyms for the respective key informant.

Learning platform: enabling mutual and collective learning

All of the interviewed BRCs initiate face-to-face interactions between groups with different knowledge to enable mutual and collective learning. Several BRCs have a multi-stakeholder advisory council or similar that provides opportunities for learning (e.g. *Channel Islands*, *São Paulo City Green Belt*, *Cape Winelands*, *Lower Morava*, *Frontenac Arch*), and many BRs initiate and facilitate workshops and forums around specific issues (e.g. *Delta del Orinoco*, *Niagara Escarpment*, *Lower Morava*, *Krivoklátsko*, *Schorfheide-Chorin*). Some BRCs offer physical meeting places to local groups, and describe themselves as 'the spider in the web' (*Channel Islands*), 'the broker of the community' and a 'neutral facilitator' (*Lower Morava*), 'the great dispatcher' (*Frontenac Arch*) and the actor that 'sets the frames for negotiation' (*Schorfheide-Chorin*).

Among the interview responses, we found examples of peer-to-peer dialogues between practitioners from different BRs or from different parts of the BR, dialogues between practitioners and scientists, dialogues between practitioners and policy-makers at different levels, and dialogues between representatives of different governmental and non-governmental sectors, business and volunteer organizations. Topics discussed in these platforms for learning include regional planning and land-use, sustainable tourism, natural resource management and biodiversity conservation. For example, *Niagara Escarpment* invited managers of all major protected areas in the region to share the mandates and objectives of their organizations and identify common management issues. They also looked for opportunities for collaborations, such as science programmes, and opportunities to connect the areas, improving regional connectivity. *Delta del Orinoco* organized a forum with 450 people, including scientists, indigenous groups and policy-makers, on the issue of land planning and the use of the forest as a resource. *Krivoklátsko* arranged a meeting with local communities on the topic of becoming a national park. Two BRs described their role as a

bridging organization (Hahn et al. 2006) in dialogues between groups of conflicting interests concerning biodiversity and economic and development issues (*Niagara Escarpment* and *Lower Morava*).

An example of a collective learning process that resulted in transformation of ecosystem management and led to new rules-in-use (sensu Ostrom 1990) was described by *Schorfheide-Chorin*:

> We have a 1000 ha lake which used to be overused through extensive fishing and tourism. We set up the Lake project in 1999 and engaged an external mediator to facilitate meetings. The project lasted two years and resulted in the 'Lake concept', a document that states what zones are protected from humans, where birds can breed, and what zones are designated for swimming and for boats, and what zones are for fishing. The process resulted in social control and self-responsibility on the agreements.

Knowledge base: building and updating a body of knowledge

Eight of the interviewed BRCs gave examples of how they facilitate the generation of new knowledge in relation to biodiversity conservation and sustainable development: they support or conduct research, monitoring, experimentation and adaptive management. In some cases, the BRCs initiate projects; in others they participate in or contribute to projects initiated by other groups, including scientists, governmental administrators and local stewards. Although they are not always involved in research and monitoring, BRCs often keep track of ongoing projects in their region and compile and store the results in libraries.

For example, *Wienerwald* explains:

> We have a lot of environmental research, e.g., monitoring in core zones, sustainable biomass utilization in forests and sustainable wildlife management (…) But the BR should be a learning site also in a broader sense, testing methods for sustainable development. So, for example, we are engaged in a research project on participation processes in the BR, hence focusing on social sustainability as well.

Schorfheide-Chorin considers research and science to be essential in their work and give the following example:

> In the early nineties we had a four-year-long research project on the conflicts between agriculture and conservation. Farmers were involved from early on in the process and the most important outcome was a couple of practice-orientated proposals of measurements on how to reduce the negative impact of modern agriculture on biodiversity and improve the results of farming. (The results of this research project were published in Flade et al. 2003)

Lower Morava recently supported and guided an assessment of the impacts of a fishpond restoration project on plant and animal populations. *Channel Islands* focuses on natural science research, by providing a state-of-the-art research vessel with full crew 200 days per year, participating in data collection and conducting data analysis. They also train volunteer divers to identify species of fish and use their observations for monitoring purposes. *São Paulo City Green Belt* coordinates multi-disciplinary groups and participates in research projects, such as the Green Belt Sub-global Assessment, which was part of the Millennium Ecosystem Assessment (2005). Finally, *Delta del Orinoco* started a programme of monitoring meteorological and water hydrodynamics in the main river, providing a Venezuelan group of experts with climate change data for modelling purposes.

Education and information centre: framing information and education to target groups and the public

All of the interviewed BRCs frame information and education to different target groups. Some BRCs design educational workshops and programmes, act as advisers or consultants, and are sources of information and knowledge on issues related to biodiversity conservation and sustainable development. They also inform and educate the public, aiming to convey nature's intrinsic values as well as the interdependence between people and nature, for example through the concept of ecosystem services. Some of these efforts are described below.

Local stewards and resource-based business. Eight of the interviewed BRCs target local stewards and resource-based businesses, such as farmers, foresters, hunters, fishermen and tourism operators. In several cases, the BRs try to achieve conservation and development simultaneously, focusing on sustainable forestry, agriculture and tourism. *Schorfheide-Chorin*, for example, has increased the share of organically farmed arable land from 0% to 28% since its designation as a BR in 1990, by providing financial incentives and advisory support to farmers. *Frontenac Arch* and *Channel Islands* have investigated and communicated how climate change will affect natural resources and what can be done by local stewards to mitigate and adapt to these effects.

Policy-makers. Six of the interviewed BRCs target politicians and civil servants at local, regional and national levels in order to improve the laws, plans and incentives that shape local management and use of ecosystems. Some provide education to these groups (*Cape Winelands*, *Lower Morava*, *Frontenac Arch*), some provide information and others try to influence decisions to protect the values of the BRs (*Schorfheide-Chorin*, *Frontenac Arch*). Some BRCs participate in societal planning processes, advocating conservation and sustainable development (*Lower Morava*, *Wienerwald*, *Cape Winelands*).

As *Frontenac Arch* describes: 'Land use changes and development pressures are the most severe threats to the values of our BR. (Hence) we play a role in educating local municipalities and the planning departments and do our best to influence land use decision makers.'

Disadvantaged groups. Among the interviewed BRs, we found three examples of educational projects that targeted disadvantaged groups aiming at improving livelihoods and the environment simultaneously. *São Paulo City Green Belt* has initiated a youth programme for eco-job training to give opportunities to the young, and to combat unemployment and environmental degradation at the same time: 'We invest in youth for long-term and actual change.' Topics include reforestation in protected areas, ecotourism, carbon markets and ecosystem services. In *Cape Winelands*, the 'Alien Clearing Programme' trains and employs people to remove eucalyptus, pine trees and other foreign species that have been planted by foresters and invaded the vulnerable Fynbos habitats, lowering the ground water table and increasing the risk for intensive forest fires.

Delta del Orinoco focuses on the livelihoods of indigenous people and has developed innovative methods to overcome language barriers:

> Indigenous groups speak only a little Spanish, and we don't speak their language, so it is difficult to communicate, even with a translator. So, we have looked for committed individuals in these communities who are willing to travel to other groups and help transfer information and knowledge. We have also done educational videos in local

> languages. (…) Our education is focused on know-how, for example on managing crops and natural resources for long-term benefits as opposed to e.g. cutting trees for short-term benefits. Other important topics are health issues, such as improving water quality to reduce child mortality. Environmental education is in our view both about economic development and the environment.

Students, consumers and citizens in general. Six BRCs support or conduct education for students and seven target citizens and consumers in general to increase people's knowledge and appreciation for nature, and to foster pro-environmental behaviour. *Wienerwald* explains:

> Most people associate BRs to guided nature tours or nature trails, and their expectations must be fulfilled. Beyond that, I try to establish new educational programmes that show the connections between behaviour and environment in various aspects of human life (…) We are situated near the city of Vienna and we find it important to connect people to their direct surroundings, and try to improve nature at the door step. Nature starts here.

BRCs use lectures, movies, websites and outdoor excursions, guided tours, and hands-on projects where people are invited to participate in restoration and monitoring efforts. Several BRCs have visitor centres with information and educational facilities like libraries, meeting rooms or even laboratories (e.g. *Krivoklátsko*, *Schorfheide-Chorin*, *Frontenac Arch*, *Channel Islands*).

Schorfheide-Chorin explains:

> We have a programme where school children come two hours every week from the age of seven to the age of 17, to learn about ecology, biodiversity, forestry, agriculture, fishery and bee keeping. Ecosystem services are very important and we communicate why ecosystems are important for living. We focus on outdoor excursions and practical work such as clearing meadows and counting geese in the autumn. Now, we see some of the children coming back as grown-ups to work with us as volunteers.

Discussion

The survey results suggest a discrepancy between the stated mission of the MAB programme and the activities taking place on the ground in BRs, considering the many sites that did not fulfil our potential learning site criteria. However, 79 respondents did report activities related to one or several categories of learning opportunities that potentially contribute to social–ecological resilience and sustainability. Follow-up interviews with 10 of these respondents revealed a rich variety of approaches taken and groups targeted by these BRCs. Although we cannot draw any firm conclusions about the actual outcomes of these learning opportunities, the results indicate that many BRs have the potential to function as learning sites for social–ecological resilience.

First, all 79 sites reporting learning activities provide platforms for dialogue between people with different perspectives, potentially enabling learning between different knowledge systems, such as indigenous knowledge (Gadgil, Berkes, and Folke 1993), local ecological knowledge (as defined by Olsson and Folke 2001) and scientific knowledge (Reid et al. 2006; Ballard, Fernandez-Gimenez, and Sturtevant 2008), and between decision-makers at different levels (Cash and Moser 2000), such as local stewards (Schultz, Folke, and Olsson 2007) and national governmental administrations. These platforms provide a first step in management by mutual learning (Stoll-Kleemann and Welp 2008). In this sense, some BRCs seem to function as 'bridging organizations' (Brown 1991; Westley 1995; Hahn et al. 2006; Pahl-Wostl et al.

2007; Berkes 2009) that can play important roles in mobilizing collective action in times of crises. Furthermore, such BRCs may provide a filter to exogenous drivers of change, such as climate change, or change in national policies, through their connections to sources of knowledge and power generated at other scales (e.g. scientists and national policy-makers). Face-to-face interaction has been identified as a crucial condition for successful collaborative governance (Ansell and Gash 2007) and even though our data do not show to what extent multiple-loop social learning takes place in these settings, the Lake project in *Schorfheide-Chorin* illustrates that learning platforms set up by BRCs can indeed transform governance towards ecosystem management.

Second, most of the sites support research and monitoring, thereby increasing the possibility for society to detect changes in the biosphere and for established facts to be revised. BRCs that coordinate such initiatives and compile the results can contribute to a systemic and dynamic understanding of social–ecological systems that forms the basis for adaptive governance (Folke et al. 2005).

Third, by framing information and education to specific groups BRCs enable learning in relation to management practices as well as the revision of institutions that frame these practices. In this context, BRCs choose to target local stewards and resource-based businesses (including farmers, fishermen, foresters and tourism operators) and policy-makers that influence land-use planning. By providing education and training to disadvantaged groups, some BRCs aim at improving livelihoods and the environment simultaneously.

The different ways that BRCs convey the interdependence between nature and society and nature's intrinsic values to students and the public have the potential to affect people's values, attitudes and beliefs, eventually supporting pro-environmental behaviour in their roles as consumers and citizens. BRs provide spaces for interaction between people and nature, with the potential of supporting and restoring sense-of-place and the emotional connections to the landscape (Miller 2005; Andersson, Barthel, and Ahrné 2007). In the resilience literature, world views and mental models are sometimes described as underlying variables that affect resilience of social–ecological systems (Berkes and Folke 1998; Gunderson and Holling 2002; Sterling 2010). Consequently, Folke et al. (2002) conclude that policy should strengthen the perception of humanity and nature as interdependent and interacting.

Through the survey and interviews, we have identified three BRCs that seem to combine learning through adaptive co-management and environmental education on the ground (*Channel Islands*, *Schorfheide-Chorin* and *Wienerwald*). As described in the 'Results' section, they enable mutual and collective learning in face-to-face interactions, they continuously build and update a body of knowledge through research and monitoring, and they frame information and education to different groups. These BRCs build their knowledge base on both scientific and experiential knowledge, they connect the groups involved in direct management of ecosystems to policy-makers at other levels and they reach out to the general public. In the light of the terminology introduced earlier by Vare and Scott (2007) of ESD 1 and ESD 2 of learning, these BRs seem to create opportunities for learning of both types. They target behavioural change among citizens and students through education and exhibitions (ESD 1), but they also function as mediators between different actors at different levels, allowing for open-ended and multiple-loop learning that can change planning procedures, law and governance structures and frameworks (ESD 2). We argue that further studies in BRs like these could deepen our understanding of the outcomes of such an approach, as well as the practical implications of facilitating learning for social–ecological resilience.

Although the numerous ways in which BRCs provide learning opportunities locally are striking, few BRs have the capacity to provide all of them. Time and resource constraints necessitate strategic choices and how they are made is to a large extent context-dependent. An interesting trade-off regards targeting people who have a direct and visible impact on local ecosystems, such as local stewards, resource-based businesses and policy-makers, versus trying to raise general environmental awareness among people who have a more indirect impact through their choices as consumers and citizens. The former might render immediate effects on the quality of management (Brody 2003) and visible effects on local ecosystems, whereas the latter may have more long-term and unclear effects on sustainability. Another trade-off regards building, updating and continuously questioning a body of knowledge on the one hand, and conveying (reasonably) established facts to target groups on the other.

The multiple objectives of protecting biodiversity, fostering sustainable development and providing opportunities for learning are also potential trade-offs. However, our analysis shows that these goals are not necessarily contradicting. The potential learning site BRs consider themselves to be more effective than the others, both in biodiversity conservation and in fostering sustainable development. In fact, environmental education was ranked as the most important factor influencing BR success in a parallel global survey to 213 BR managers in 78 countries (Stoll-Kleemann and Welp 2008). However, because there is no systematic assessment of effectiveness of management in BRs, it is currently impossible to draw firm conclusions about the influence of learning opportunities created by BRCs.

The term 'learning site' raises questions about who is supposed to learn, and what is supposed to be learned. Most of the learning opportunities identified in this study are provided locally and even though the lessons learned are possibly spread elsewhere through the networks of participants we have found little evidence of cross-scale learning taking place in the World Network of Biosphere Reserves. It seems that a lot remains to be done if BRs are to live up to the ambition of being learning sites for sustainable development or sources of resilience on a global scale. There is a tension between engaging in participatory, field-based learning that generates context-specific knowledge, and learning that aims at generating knowledge that is general enough to feed into wider policy-making (Edwards 1997). There is also a tension between action and reflection; or time spent providing learning opportunities versus time spent reflecting upon and evaluating actions taken to improve strategies. Arguably, there is also an inherent tension between the dual roles of BRs as 'sites of excellence' and 'learning sites' as stated in the Statutory Framework and the Madrid Action Plan (UNESCO 1996, 2008). The former brings expectations of success and implies that the BR designation is an award that BRCs need to live up to, but the latter implies experimentation and reflection on both successes and failures (Gunderson et al. 2006). We have found little evidence of systemic evaluations of learning and conservation outcomes of the actions taken by BRCs and there is no coherent set of indicators used that could enable comparisons (Bertzky and Stoll-Kleemann 2009). This makes it difficult to gather general lessons about what approaches are effective. There is even less evidence that lessons learned in BRs are communicated outside and between these regions and several of the interview respondents called for more communication of lessons learned and best practices between BRs. So, for the full learning potential of the World Network of Biosphere Reserves to be realized, both incentives and capacities for evaluation and communication would need to be strengthened. A useful framework for evaluation is suggested by Plummer and Armitage (2007), directing attention to ecosystem

conditions, livelihood outcomes, and process and institutional conditions. They also offer scale-specific parameters for each component to facilitate systematic learning from experience and encourage cross-site comparisons.

A promising initiative to facilitate communication has been taken by the GoBi Research Group at Ernst-Ludwig Arndt University of Greifswald (Germany). One of the tasks of their recently launched 'Global Centre for Biosphere Reserve Advancement' is to build an online communication platform for BR practitioners and researchers, including updated contact details to participants, a database of resources such as practical tools, research, reports and a discussion forum for topics related to biodiversity conservation and sustainable development in BRs (www.biosphere-research.org). Ideally, such a platform for dialogue could catalyse a learning community or an adaptive learning network (sensu Davidson-Hunt 2006) for sustainability, and following the effects of this initiative would be an interesting subject for future studies.

Learning happens everywhere, all the time. This study has focused on the learning opportunities created in BRs in relation to sustainability and resilience. It has demonstrated that BRs have the potential to illuminate the practical dimensions of this endeavour and that research in sites like these can generate important insights on how learning for social–ecological resilience can be facilitated. The actual effects of such learning opportunities, in terms of environmental outcomes, and in terms of social–ecological resilience, remain as important research questions for future studies.

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Notes

1. Sustainability and sustainable development are used as synonyms in this paper, and defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development 1987).
2. Learning is here defined in line with the special issue, as a process of change in the way we look upon the world – our thoughts, feelings and actions – which is dependent on the learner, the object of learning and the physical/ecological, social, cultural and economic situation and setting.

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