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Sustaining Home: Canadian Biosphere Reserves in Action

Striking Balance @ www.strikingbalance.ca

ABSTRACT: Below is an excerpt from Sustaining Home discussing the beginning of biosphere reserves in a Canada context. The full eBook of Sustaining Home, featuring interactive images, maps and video is now available on the Apple iBooks Store:

https://itunes.apple.com/us/book/id1168439372

UNESCO's Man and the Biosphere Programme was launched in 1971. Since the beginning, the program has explicitly sought to better understand how human activities were generating changes in the biosphere — that thin layer of life at the earth's surface.

MAB also had an explicitly normative orientation: to seek the best path to achieve desired outcomes. MAB scientists (including social scientists) hoped their research findings could raise public and political awareness of changes happening in the global biosphere to encourage individual and collective changes in decisions and policies affecting the environment. In short, researchers wanted to generate results that would inform knowledge users — local practitioners and decision-makers at all levels.

MAB's earliest research programs focused on what creators called the "human-use system," not exactly an

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ecosystem, but rather, a system where humans and environments interact. This concept also emphasized that the research focus was *not* to be placed on untouched or isolated ecosystems, but that explicit attention be given to the interconnections between humans and the environment.

In 1971, placing people at the heart of conservation research and practice was a radical step. Previously, research in ecology had typically focused on untouched systems and viewed human activities solely as disturbances. Encouraging social scientists to work with natural scientists on these issues was also a significant departure from previous research programs.

The MAB Programme established 14 international project areas for research. Some of these project areas focused on the interrelationships between humans and ecosystems, while others focused on particular effects or processes deemed to be of global significance (such as perceptions and attitudes about the environment, and the use of pesticides). Each project area was to generate research that could be used to better understand the effects of human activities on the environment; this in turn could be used to improve decision-making about environment and sustainability. There was also an emphasis on training the next generation of researchers and practitioners, particularly in developing countries.

Biosphere reserves were created under Project Area 8 of the MAB Programme. This project area entitled, "Conservation of natural areas and of the genetic material they contain", involved establishing a set of representative ecosystems around the world as sites of research, monitoring, education, and training. The greatest emphasis was placed on the conservation of biological diversity; biosphere reserves were supposed to become sites where conservation practices could be introduced, monitored, and reviewed, and where scientists could work with local managers to learn what worked and what failed, and to translate those lessons into best practices.

Particularly in developing countries, biosphere reserves were to be sites where local people could be trained to become applied ecologists or conservation managers. As places of learning, biosphere reserves were sometimes referred to as "living laboratories." Importantly, biosphere reserve sites were to be part of an international network so that findings could be compared across the network and researchers and practitioners could learn from practices elsewhere.

Despite its ambitious goals, funding for the MAB Programme was modest at best. In 1984, UNESCO, the United Nations Environment Programme (UNEP), and the then-named International Union for Conservation and Natural Resources (IUCN) jointly completed the *Action Plan for Biosphere Reserves*. However, the expected funding from UNEP and IUCN to implement the international action plan never materialized; in the words of Dr. Michel Batisse, it became "an action plan without action."[1]

Indeed, biosphere reserves have always run on a shoestring; for example, a study in 1992 indicated that the IUCN ran its programs with a professional and general service staff that numbered more than 500 employees, while the international MAB Programme in Paris had only 40. Consequently, MAB relied heavily on financial and logistical support offered by individual nation states. Canada's role was enthusiastic and formative at the international level, but (as described later in this chapter) provincial and federal agencies did not provide a solid financial foundation for the program at home.

During the 1970s, a global economic recession reduced governmental enthusiasm for the program in many "developed" countries (including Canada), and not surprisingly, developing countries were not in a position to lead the program. There were also practical challenges associated with establishing and maintaining interdisciplinary research teams focused on problem-driven research.

While MAB's research and training opportunities were showcased in an international conference in 1981, entitled "Ecology in Action," the program overall was not well publicized and its goals and successes were not well understood by politicians or ordinary people living in participating countries. Internationally, the program's uptake was uneven, and some project areas were not well developed. Many of the project themes were dropped, and project teams were disbanded. By the mid-1990s, MAB's 14 international project areas fell away entirely, and many of the anticipated benefits of an international network were never realized.

[1] Batisse 2001

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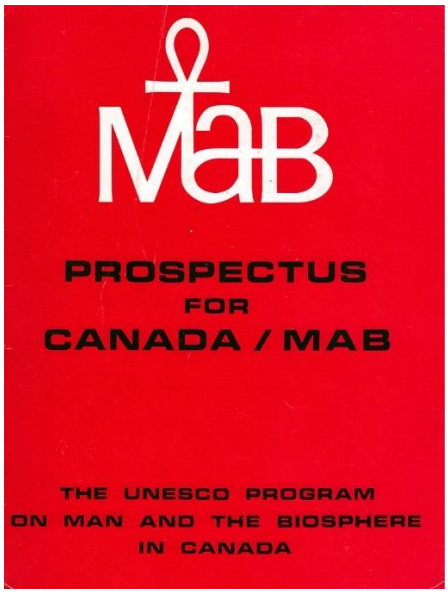

Cover of an early prospectus for Canada/MAB. Courtesy *Dr. Patricia Roberts-Pichette and CCUNESCO*

The evolution of the biosphere reserve concept

Despite the waning of the MAB's broader project areas, biosphere reserves — the small seeds sown under Project Area 8 — were taking root. The network grew quickly, beginning in 1974 with 24 sites in five countries. By 1981, 201 were designated; by 1992, 300 biosphere reserves had been established in 75 countries. In 2008, there were 531 biosphere reserves in 105 countries. Canada began slowly, with only two biosphere reserves established in the 1970s. The greatest growth was in the 2000s, when nine biosphere reserves were created. By 2016, Canada had 18 biosphere reserves.

The evolutionary history of biosphere reserves can be divided into two periods: the first period is from their origins in the MAB Programme up to 1995; the second period is from 1996 to the present. The division point marks the time when MAB officially adopted a statutory framework that set out formal conditions for how the World Network of Biosphere Reserves was to operate. At the same time, sustainable development was established as a guiding function for biosphere reserves; these changes were embodied in the *Seville Strategy*, an action plan that guided biosphere reserves until 2008.

Period One: Conservation, research, and education

At the beginning of the first period, in 1974, a special task force convened jointly by UNESCO and UNEP drew up a set of objectives and characteristics for the international network of research sites, or biosphere reserves. It is significant that these objectives were established with UNEP rather than with the United Nations Development Program (UNDP), a clear signal that biosphere reserves were to serve environmental and conservation objectives. This focus was reinforced by the three primary objectives of the international network:

> to conserve for present and future human use the diversity and integrity of biotic communities of plants and animals within natural ecosystems, and to safeguard the genetic diversity of species on which their continuing evolution depends;
> to provide areas for ecological and environmental research including, particularly, baselines studies, both within and adjacent to these reserves, such research to be consistent with objective (1) above; and to provide facilities for education and training.[2]

One can see that the first objective — safeguarding biodiversity — indicated that biosphere reserves were to be a type of protected area. The word "reserve" reinforced this idea and indeed, biosphere reserves shared similar objectives with other kinds of research sites and protected areas around the world. The Americans had experimental forests and national parks, the then USSR had *zapovedniks*, while Britain had nature reserves. Biosphere reserves, however, were to have some important differences from these other designations. The aim with biosphere reserves was to understand and redress *widespread* environmental challenges rather than focus on places with exceptional qualities.[3] They were also to be maintained with — and for — people.

[2] UNESCO 1974

[3] Batisse 1982

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The town of Mont Saint-Hilaire abuts the mountain, the core of Canada's first bio-sphere reserve. Mitigating the impact of the increasing local population on both the mountain and other natural areas is a focus of the biosphere reserve. Courtesy *Striking Balance*

Because they were to foster an understanding of widespread challenges, biosphere reserves were to be *representative* ecosystems rather than unique ecosystems set aside for protection, and were to include natural and semi-natural ecosystems, including areas where ecosystems had been degraded but still had the potential for restoration. Individual sites were also to be configured differently from previously existing protected areas, such as national parks or nature reserves; each was to have a strictly protected area at its core (such as a national park or a wildlife sanctuary) and concentric rings of increasing human influence.

The classical configuration resembled a fried egg and would allow one to study the effects of human activities across space and over time (Figure 2). It would also allow for "manipulative research" — a strategy where researchers set up experiments outdoors, modify or "disturb" the ecosystem, and then study the results.

Over time, these research and training objectives merged into one objective, described as the "logistics" function of biosphere reserves, and today, "logistics" refers to a wide range of ideals. Training has given way to broader concepts of education, which can include local residents, visitors, and practitioners with a range of interests and perspectives and from various sectors of society. Education now involves more than classroom education and includes activities such as demonstration, raising interest and awareness, and outreach. Citizen and community science — described in greater detail in Chapter 4 — are also a part of the logistics function.

And, for some biosphere reserves, education also means building capacity, i.e., helping local people understand the environmental, social, and economic challenges within their communities and seeking out tools that can be applied locally to address those challenges. These tools may involve activities such as regular monitoring of local changes, collaborative planning exercises, skills development, and so on.

Biosphere reserves today serve an important additional function: to become models of sustainable development. This function is not entirely new; when biosphere reserves were first established, some of the creators spoke about the reserves' role in promoting "integrated development" and in creating production systems (primarily agricultural systems) that would maintain ecosystem functions and processes.

Despite these early ideas, the development function was neither clearly articulated nor formally implemented. Instead, in the first decade, many biosphere reserves were established on top of pre-existing protected areas such as national parks, zapovedniks, and nature reserves. (By 1981, about 84 percent of biosphere reserves were designated in such a way).[4] The restrictions that had been placed on the original protected areas were effectively — if unofficially — placed on biosphere reserves as well, with the result that involvement of local people living in or near biosphere reserves was often restricted.

The international conservation community eventually became concerned that shutting people out of protected areas would not generate the conditions necessary for the long-term protection of biological diversity. Following the First International Congress on Biosphere Reserves, in 1983, Canadian researcher George Francis reflected:

... unless the goal of ecosystem conservation is linked directly to development issues, it will not progress much further in many parts of the world. While some people in industrialized countries seem to view biosphere reserves as little more than a mark of recognition for their long-established parks or nature reserves, others working in developing countries are beginning to see considerable potential in the idea of a

[4] Miller 1982

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biosphere reserve as a kind of outdoor laboratory of evolving eco-development strategies to meet the basic needs of local communities. We can look forward then to a continued evolution of the concept as both its potential and its flexibility for adaptation become more widely appreciated. [5]

Dr. Francis's comments were prescient. They foreshadowed concerns that would dominate the MAB Programme following the work of the World Commission on Environment and Development (also known as the Brundtland Commission).

In the Waterton Biosphere Reserve, ranchers like Kathy Flundra, use cattle to maintain the praire ecosystem. Courtesy *Striking Balance*

Period Two: Grappling with sustainable development

The seeds of the second period were sown when the Brundtland Commission published its final report, *Our Common Future*, in 1987. The report is credited with the widespread adoption of the term "sustainable development," and it encouraged governments to identify strategies to reconcile the imperatives of environmental protection and economic development.

The Brundtland Commission's report supported the expansion of biosphere reserves. However, it referred to biosphere reserves only according to their role in conserving biodiversity, not to their role in supporting sustainable development, and therefore led to some soul searching on the part of MAB proponents.

Early biosphere reserves were created without significant public consultation. Scientists and public servants within each nation-state had effectively made the decisions about where they should be located. By the late 1980s and early 1990s, researchers and program officers in MAB — along with external advisors — began to express concern that the goals of protecting biodiversity would not be achieved without more direct attention given to development challenges in both pre- and post-industrial countries.

Program officers and researchers affiliated with MAB examined their own practices, and pointed to a few examples of extensive local involvement in biosphere reserves. One of these was the Mapimi Biosphere Reserve in Mexico, where local people had been involved in selecting the site for the biosphere reserve and managing activities thereafter. Another was the Waterton Biosphere Reserve in Alberta, where local people were involved in implementing projects.

Dr. Anne Whyte at the Mapimí Biosphere Reserve. Courtesy *Dr. Anne Whyte*

But these were exceptions. In 1993, a study of almost 300 nomination forms revealed that information regarding the participation of local people in the proposed biosphere reserves was included in only 40 applications.6 In 1993, UNESCO reported that program officers knew very little about the status of local populations or their involvement in biosphere reserves. The report also indicated that — in some regions — local people were restricted from using parts of biosphere reserves, had little or no say in their operation, and had not been provided with specific benefits. And researchers reported that in some places,

[5] Francis Fonds

[6] UNESCO 1993

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the livelihoods of local people had declined since biosphere reserves had been created.[7]

An early meeting of biosphere reserve supporters. Courtesy *Waterton Biosphere Reserve and Larry Frith*

It is plain, then, that biosphere reserves were not immune from the criticisms levelled at protected areas more generally, where ecosystem protection had come into conflict with protecting peoples' livelihoods and well-being. The formative Canadian biosphere reserves (designated between 1978 and 1990) were not subject to the same criticisms at that time, possibly because they were established where the core protected areas were already part of the contemporary landscape, and possibly because their establishment did not alter the legal obligations or property regimes of pre-existing landowners. Another possible reason is that the concerns, interests and rights of Indigenous peoples had not been fully taken into account by mainstream Canadian society — an issue that would be raised much later among Canadian biosphere reserve practitioners and Indigenous peoples (see Chapters 7–9).

Clearly, to address these concerns, MAB had to articulate a more inclusive vision. In 1995, following its 2nd World Congress of Biosphere Reserves, the MAB Programme established the *Seville Strategy* and the *Seville Statutory Framework*. Article 3 of the Statutory Framework states the following: "[B]iosphere reserves should strive to be sites of excellence to explore and demonstrate approaches to conservation and sustainable development at a regional scale."[8]

Strategic documents from UNESCO[9] began to emphasize local engagement and knowledge as well as the need for more social science research within biosphere reserves. The *Madrid Action Plan for Biosphere Reserves*, created at the 3rd World Congress of Biosphere Reserves in 2008, guided the international network from 2008–2015. This plan suggests that sustainable development must include both an understanding of cultural diversity as well as efforts to enhance that diversity. It also directs member states to ensure that individual biosphere reserves engage in open and participatory processes that help strengthen cultural identity, values, and practices.[10]

Over time, the development function gained greater prominence. In 2015, the MAB Programme declared in its new *MAB Strategy* 2015-2025, that the World Network of Biosphere Reserves consisted of "effectively functioning models for sustainable development". The *Strategy* also committed the MAB Programme and the international network of biosphere reserves to working towards the United Nations' Sustainable Development Goals.[11] In short, by 2015, sustainable development formed the *raison d'être* for biosphere reserves.

In 2016, the 4th World Congress of Biosphere Reserves was held in Lima, Peru, where the congress upheld the new *MAB Strategy* 2015-2025 and set out the *Lima Action Plan*, designed to guide the actions of biosphere reserves until 2025.[12] Today's *MAB Strategy* does not emphasize building a network of representative ecosystems for applied research and training; instead, the guiding strategy suggests that biosphere reserves "should be representative of their biogeographic region and of significance for biodiversity conservation."[13]

The new strategy also explicitly speaks to "sustainability science" as a key mechanism to

[7] Ghimire 1991; Nyakweba 1993; Price 1996
[8] UNESCO 1996

[9] For examples, see UNESCO 2000; 2002

[10] UNESCO 2008

[11] See UNESCO-MAB 2015 and United Nations 2015

[12] UNESCO-MAB 2016

[13] UNESCO-MAB 2016

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generate, communicate, and share knowledge. According to the strategy, sustainability science is:

an integrated, problem-solving approach which draws upon scientific, traditional and Indigenous knowledge to identify, understand and address present and future economic, environmental, ethical and societal challenges which are related to sustainable development. At a biosphere reserve level, this requires collaboration between all the different stakeholders, including scientists, policy makers, members of local communities, and the private sector.[14]

The *Lima Action Plan* reinforces the overall strategy with specific actions directing members to ensure open and participatory selection, planning, and implementation of biosphere reserves and to contribute to the implementation of the (United Nations') Sustainable Development Goals, which include taking into consideration the rights of Indigenous peoples.

Canadian Biosphere Reserves Association President, Jean-Philippe Messier, presents at the 4th World Congress in Lima. Courtesy *Xavier le Guyader*

Canada in relation to the international program, 1970s–present

Canadians are credited with championing the integration of natural and social sciences in the conceptualization and execution of applied research about human-environment relations. Two prominent Canadian scientists, Drs. George Francis and Fred Roots, have already been noted. Others, such as Dr. Fikret Berkes, also served on the Canadian MAB Committee during the 1990s. But an earlier pioneer was Dr. Anne Whyte, a geographer from the University of Toronto who was later seconded to UNESCO in Paris to lead the MAB project areas on environmental perception.

During the 1970s and 1980s, Dr. Whyte lobbied to ensure that both natural and social scientists became involved in MAB research initiatives. She developed a set of guidelines for studying environmental perception, and she drew from the methods and approaches of different disciplines and evaluated them for their potential application across a range of environmental and cultural contexts.[15] While working in Paris, she identified points of convergence between the natural and social sciences as well as the challenges of working together (seeking to reinforce the former and address the latter). For example, she identified how researchers could draw on theories and frameworks that would embrace natural and social science contributions. She also encouraged natural and social scientists to work together to better understand each other's use of language, methods, and ways of knowing in an effort to improve understanding of human-environment relations. Dr. Whyte also advocated greater involvement of local people in research projects sponsored by MAB.[16]

[14] UNESCO-MAB 2016

[15] Whyte 1977

[16] Whyte 1982

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Dr. Anne Whyte. Courtesy *Anne Whyte*

Other Canadians also contributed in very practical ways.[17] The Canadian MAB Committee was the first national committee within MAB to establish national-level criteria for nominating biosphere reserves — criteria which were established and then revised in three documents (1976, 1977, 1982) that were shared and adapted (or adopted) in other countries.[18] The criteria included seeking representation from each of the world's ecological regions at that time, called "biogeographical provinces." These provinces were mapped by a Hungarian biologist and biogeographer, Miklos Udvardy, and adopted by UNESCO as a guide for selecting biosphere reserves around the world.

The 1980s drove home the expectation of problem-driven research, which sustainability scientists now call "use inspired" research.[19] In 1987, Canada developed a *National Action Plan* designed to link the actions of biosphere reserves to provincial and national conservation strategies. Its authors believed that the action plan would form part of Canada's response to the Brundtland Commission and the World Conservation Strategy. The plan articulated Canada's strong support for an international network of representative ecosystems, envisioning that there should be at least one biosphere reserve in each of the world's biogeographic provinces within Canadian borders. At the time, there were four Canadian biosphere reserves (at Mont Saint-Hilaire, QC, Waterton, AB, Long Point, ON, and Riding Mountain, MB); Canada's plan identified the desire for nine new biosphere reserves, for a total of 13. The plan was strong in its ambition, but weak in its capacity for action at the senior government (provincial and federal) levels.

The Waterton Biosphere Reserve is at the intersection of the Prairie and Montane Cordillera biogeographic provinces. This intersection can be seen from Julia Palmer's ranch. Courtesy *Striking Balance*

[17] See end of article for past Canada MAB-related committees

[18] Canadian Committee for MAB 1975; 1977; 1982

[19] For examples, see Kates et al. 2001; Kates 2011

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During the 1990s, federal oversight of the Canadian contribution to the MAB Programme and biosphere reserves fell apart, and by the mid-1990s the Canadian MAB Committee became inactive. Nevertheless, there was a flurry of activity as people in various regions began to develop nomination proposals. Often taking years to move from concept to designation, these proposals were drafted in the absence of any real governmental support. To the credit of George Francis and Fred Roots, Canada submitted nine new biosphere reserve nominations in the 2000s; all of those nominations had been developed over many years during the 1990s.

Canadian biosphere reserve practitioners were working hard, both within and beyond their regions. In 1980, the Canadian MAB Committee established a Biosphere Reserves Working Group to foster cooperation among the existing biosphere reserves and to facilitate the development of new Canadian reserves. Under the stewardship of the Working Group, four new biosphere reserves were designated by 1990, bringing the total number of Canadian biosphere reserves to six. From the early 1990s onwards, Parks Canada and Environment Canada's Ecological Monitoring and Assessment Network supported a number of initiatives, such as the development of biodiversity monitoring plots in biosphere reserves across the country. In 1996, the Working Group was re-formed with representatives from the existing biosphere reserves to become the Canadian Biosphere Reserves Association (CBRA). CBRA was incorporated in 1997 to enhance support and program activities across the national network. In 1998, CBRA received official charitable status.

From 1997–2001, the six biosphere reserves conducted a joint study of landscape change within each locality under a study agreement with Environment Canada, the Ontario Ministry of Environment, and the CBRA. This project — the network's first collective research effort – provided knowledge about land cover change in those regions since European settlement.

The year 2002 was important internationally. The World Summit on Sustainable Development was to be held in Johannesburg, South Africa, and Canada's federal government wanted to showcase the work of biosphere reserves. Parks Canada was able to secure funding from the then Canadian Secretariat for the World Summit on Sustainable Development, from which each biosphere reserve received about $10,000 to complete a cooperation plan to demonstrate how biosphere reserves work with regional partners to deliver "sustainable development." One biosphere reserve practitioner, Éric Malka, at the Mont Saint-Hilaire Biosphere Reserve, was selected and sponsored to attend this event.

Despite the summit's high profile, little of that benefit trickled down to the Canadian biosphere reserves, and they continued to struggle financially. In 2002, a workshop was held at Carleton University involving representatives from federal and provincial agencies, nongovernmental organizations, organizations such as the then National Round Table on Environment and Economy, and foundations such as TD Friends of the Environment Foundation. The workshop preceded the World Summit and was designed to showcase the work of biosphere reserves and identify potential funding partners that could provide reliable support for the network. Participants raised lots of good ideas, but ultimately the desired assistance did not materialize. At the end of the workshop, John Whitaker, a longstanding CBRA member, summarized his frustration: "The Canadian network is a single parent, working two jobs, trying to raise 11 children, receiving suggestions but no support from neighbours."

Optimism abounded in Canada in the early 2010s. CBRA had signed a contribution agreement with Environment Canada, and with a university researcher had secured funding from the national Social Sciences and Humanities Research Council (SSHRC) to engage in a partnership designed to improve biosphere reserve effectiveness through social learning and networking strategies. Much good came from these short-lived efforts but sadly, the contribution agreement was cut short two years before its expiry and was not renewed. The national executive was laid off, as were several local coordinators. The SSHRC partnership expired after three years, although some initiatives from it have continued (See Chapters 7 and 8).

Ultimately, though, 14 years later one could echo those words of John Whitaker, except that now there are 18 children in the biosphere reserve family.

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John Whitaker at the Riding Mountain Biosphere Reserve. Courtesy *Maureen Reed*

The Canadian MAB children: Forever orphans?

Canadians have done a lot to support the UNESCO MAB program, establish and execute biosphere reserve ideals, and participate in the international network. Countless volunteer hours have been spent on individual biosphere reserves ‹ in national efforts and in linking with the international program. Researchers and Practitioners alike have worked on policies and practices to enhance sustainability around the country, and have also been pioneers in conceptualizing and realizing the concepts of sustainability science.

A significant challenge has been executing a program that has no obvious "home." Municipalities may be located within biosphere reserves, but they do not have specified mandates for environmental programs. Provincial governments, and now territorial governments, are largely responsible for managing the lands and natural resources that exist within their boundaries. The federal government is responsible for implementing international commitments and programs. Hence, there are many levels of government with potential interests in biosphere reserve objectives, but there is no clear level at which these interests might be translated into responsibilities.

To compound the confusion, within the federal government, both Environment Canada and Parks Canada have responsibilities directly related to biosphere reserves. However, so do other agencies, such as Fisheries and Oceans Canada, Natural Resources Canada, Agriculture and Agrifood Canada, and Indigenous Affairs and Northern Development Canada. But because biosphere reserves span environmental, economic, *and* social concerns, no one agency has a defined mandate to support it. There has been little leadership, and consequently, little by way of sustained funding or logistical support.

While Canadians have done a lot, Canada has not. But Canada is not alone; the challenge of implementing its own program also faces UNESCO, an organization that has also worked with limited financial resources and which has seen dramatic drops in funding over its lifespan due to the withdrawal of funding commitments by individual nation states. Despite these limitations, biosphere reserve practitioners continue to dedicate their efforts to conservation and sustainable development through a variety of programs and offerings.

Canadian MAB Committee of the Canadian Commission for UNESCO, 2010–2016

- Stan Boychuk (Chair) – Private Consultant, Victoria (BC)
- Maureen Reed (Vice-Chair) – University of Saskatchewan, Saskatoon (SK)
- Jean-Phillipe Messier – President, Canadian Biosphere Reserves Association and Executive Director, Manicouagan-Uapishka Biosphere Reserve, Baie-Comeau (QC)
- Marc-André Guertein (to December 2015) – Assistant Professor, Sherbrooke University, Sherbrooke (QC)
- Eli Enns – Regional Coordinator, North America Indigenous Peoples and Community Conserved Territories and Areas (ICCA) Consortium, Victoria (BC)

Canada MAB working group on biosphere reserves, 1982

- Dr. George R. Francis (Chair) – Professor, Man-Environment Studies, University of Waterloo, Waterloo (ON)
- Michel Drew – Mont St.-Hilaire Nature Centre, Mont St. Hilaire (QC)
- Harold Eidsvik – Senior Policy Advisor, Programme Policy Group, Parks Canada, Ottawa (ON)
- Dr. Bristol Foster – Ecological Reserves Unit, Ministry of Lands, Parks and Housing (BC)
- Geoff Holland – Director, Ocean and Aquatic Sciences, Department of Fisheries and Oceans, Ottawa (ON)
- Frank Manual – Deputy Minister, Department of Tourism, Recreation and Culture, St. John's (NL)

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- Dr. Norman Simmons – Assistant Deputy Minister, Department of Renewable Resources, Yellowknife, (NWT)

The 1987 Action Plan committee

- Richard Bill, Inland Waters and Lands Directorate, Environment Canada, Ottawa (ON)
- Environment Canada and Fred Roots supported its preparation
- Alex T. Davidson wrote the preface, Environment Canada, Ottawa (ON)
- George Francis chaired the working group on biosphere reserves

A workshop on biosphere reserves that developed the guidelines for selecting biosphere reserves in Canada (1975) included:

- Dr. Gordon Nelson (Chair) – Department of Geography, University of Western Ontario, London (ON)
- Mr. Iain Baines – Environmental Management Services, Department of the Environment, Ottawa, (ON)
- Dr. Bristol Foster – Coordinator, Ecological Reserves, Victoria (BC)
- Dr. Dennis Kerfoot – Physical Scientist, Arctic Land Use Research Station, Ottawa (ON)
- Professeur Gille Lemieux – Department de Pedologie et d'ecolgie, Faculte de Foresterie et de Geodesie, Universtie de Laval, Québec City, (QC)
- Dr. Everett Peterson – Western Ecological Services, Edmonton (AB)
- Dr. I.C.M. Place – Canadian Forest Service, Department of Environment Ottawa (ON)
- Mr. Peter Poole – Parks System Planning Division, Parks Canada, Ottawa (ON)
- Dr. Normal Simmons – Canadian Wildlife Service, Yellowknife (NWT)
- Dr. John Theberge – School of Urban and Regional Planning, University of Waterloo, Waterloo (ON)
- Mr. John Whiting – The National Museum of National Sciences, Ottawa (ON)

Members of the MAB Subcommittee on Criteria (for evaluation process, project selection, and program review) 1975

- P.M. Bird (Chair) – International Program Branch, Liaison and Coordination Directorate, Environment Canada, Ottawa (ON)
- H.F. Fletcher – Fisheries Research Board Service, Ottawa (ON)
- P. Jacobs – Faculté d'Aménagement, Universtié de Montréal, Montréal, (QC)
- D.R. Miller – Department of Biological Sciences, National Research Council, Ottawa (ON)
- P. Roberts-Pichette – Executive Secretary, Canadian MAB Programme Secretariat, Liaison and Coordination Directorate, Environment Canada, Ottawa (ON)
- D. Sewell – Department of Geography, University of Victoria, Victoria (BC)

[1] Canadian Committee for MAB 1975; 1977; 1982

[1] For examples, see Kates et al. 2001; Kates 2011

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Land Crab Management for Conservation and Tourism Development in UNESCO Cu Lao Cham – Hoi An Biosphere Reserve, Vietnam

Thao Ngoc Le - Management Board of Cu Lao Cham – Hoi An Biosphere Reserve, Vietnam.

Bieke Abelshausen - Vrije Universiteit Brussel, Belgium

Tri Hoang Nguyen - Hanoi National University of Education, President and Secretary General – Vietnam MAB National Committee

ABSTRACT: Land crabs, *Gecarcoidea lalandii*, native to forest and tidal areas, are considered a tropic factor sustaining the food chain and food web in marine-mountain ecosystem/ecotone, and a valuable source of nutrition for tourism and livelihood development. Land crab populations are used as indicators for forest and marine ecosystems health and are considered a contributing factor to the sustainable development of Island communities. Cham Island, located in Quang Nam province in central coastal Vietnam is explored as a case study to examine the influence that socio-economic development and natural disasters can have on land crab populations and associated benefits for sustainable development. Attempt for solutions have been offered and implemented by governments, managers, the scientific and grassroots communities to aid in the conservation and sustainable development of this valuable resource.

Introduction

Cham archipelago is known as a collection of beautiful, untouched islands with wild values and outstanding biodiversity, both in the forest and under the sea. With an area of 5.175 ha water surface surrounding 8 islands, it is the place for more than 311 hectares of coral reefs, 50 hectares of sea grass, seaweed, and more than 10 beaches [10] with fine white sand, and the soft tidal cliffs surrounding the islands. These are important habitats, home to numerous marine species and human development.

Not only outstanding in landscaping marine biodiversity, Cham Islands also owns primeval green forests covering the whole island. In addition to providing forest products, Cham Islands is a place of rare genetic conservation; specifically, the reservoir of fresh water which supplies residents on the island. These situations are the decisive factors for land crab life.

The outstanding value of biodiversity and cultural history of Cham Islands have made it a special attraction for tourists. The process of formation and preservation of these values have been intimately connected with the history of Hoi An ancient town: this connection served as the basis for the United Nations Educational, Scientific and Cultural Organization (UNESCO) to recognize Cham Islands as the core area of the Cu Lao Cham – Hoi An Biosphere Reserve [19].

KINGDOM	**ANIMALIA**
PHYLUM	Arthropoda
SUBPHYLUM	Crustacea
CLASS	Malacostraca
ORDER	Decapoda
INFRAORDER	Brachyuran
FAMILY	Gecarcinidae
GENUS	*Gecarcoidea*
SPECIES	***Gecarcoidea lalandii*** ***(***H. Milne Edwards, 1837***)***

Table 1: Land crab identification [21]

The land crab population in Cham Islands.

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Figure 1: Land crab *Gecarcoidea lalandii* (Thao, N. L)

The distribution of *G. lalandii* on the Cham Islands knows the highest species occurrence on Hon Lao Island. Hon Lao is the largest and only inhabited island of the archipelago. *G. lalandii* is a nocturnal species that inhabits caves. Their habitat perimeter extends between 1 to 12 meters around their cave [8]. Based on local ecological knowledge from the Cu Lao Cham residents a population density of several hundred crabs per cave is observed, which is perceived as a high population density with the highest intensity on Hon Lao island, one of the eight island of the Cham archipelago. Land crab population size on Cham islands varies between 30,000 and 35,000 individuals [1], [6], [8], [15], [17]. Their main food sources consist of vegetables, forest leaves, worms, and dead animals. The size of female land crabs varies according to their habitat. Female size varies between 50-60 mm on Hon La, Hon Tai and Hon Dai and 70-80mm on Hon Lao [8]. This variation in size depending on their habitat is possibly due to the difference in forest cover.

Reproductive characteristics of G. Lalandii on Cham Islands.

The reproductive season is initiated in the transition period between the rainy and dry season (end of March, beginning of April). The occurrence of thunderstorms appears to trigger the breeding pattern of land crabs, as sexually mature crabs leave their caves after storms and migrate to nearby streams for breeding. The breeding season of *G. lalandii* occurs between June and September [1] [15] [17]. Measurement data gathered by community science volunteers, local fishermen, shows that land crabs carrying eggs have a size varying between 40 to 78 mm, with the highest frequency around 60mm [12], [14]. The largest size, 80mm, was found on Hon Lao Island [8]. The breeding process entails the nocturnal migration of female crabs from their caves to tidal areas. Female crabs use their pincers to remove the eggs and release them in the ocean. This process is very fast, varying from 5 to 10 minutes, after which they quickly return to their forest caves [8].

Figure 2.1: The *G. lalandii* male in Cham Islands [15]

Figure 2.2: The *G. lalandii* female in Cham Islands [15]

After being released into the sea water, land crab larvae spend an average of 7 to 10 days developing into juvenile crab during which they change their shell several times. Juveniles crawl to the shore and live near the water's edge until they have relatively grown up and migrate into the forest where they live until maturity and only return to sea for spawning by which they complete their lifecycle.

According to Liu and Jeng, 2007, a female crab *(G. lalandii)* can spread from 70,000 to 210,000 larvae [8]. However, according to Damholdt (2006) female crabs

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at Cham Island carry 35,992 to 248,528 eggs as the number of eggs depends on the size of the female crab [6]. Various factors have been suggested as possible reasons: predation animals, habitat limitation, inadequate food supply, shrinkage of living space and barriers in their migrant path.

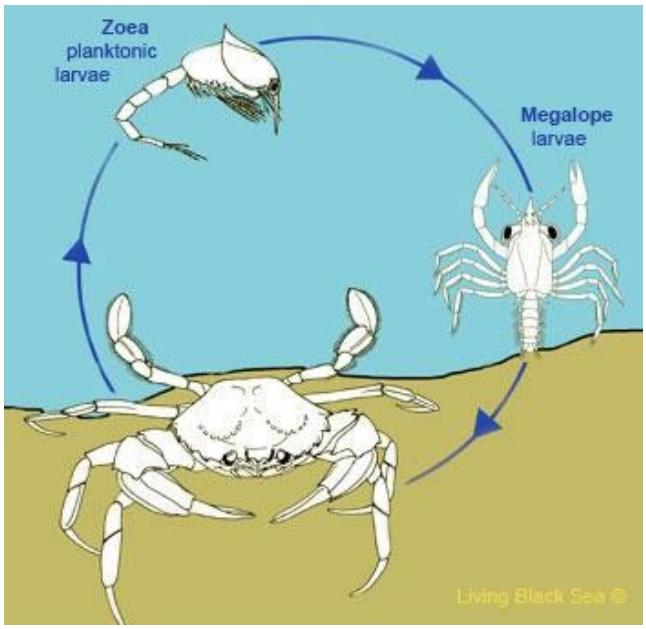

Figure 3. The *G. lalandii* lifecycle [20].

Ecological significance of land crab population on Cham Islands.

Land crabs are extremely important for the ecosystem in general and in particular for forest ecosystems. They help transfer the energy flow from land into the sea and back, promote the biogeochemical cycle by consuming falling objects in the forest litter, reduce erosion, activate the soil structure and improve groundwater resources. In addition, land crabs have a positive role in seed dispersal and enhancing flora biodiversity of the rainforest [8] Thus, the evolution of land crab population will reflect the situation and health of forest ecosystems on Cham Islands.

Community understanding of biological and ecological characteristics of the land crab.

From different thinking and understanding of land crab life, research on Cham Islands have added scientific information for local people for understanding on: where land crabs live, what their ecological environment is, what their food source is, what its life cycle is, how to protect the land crab population in the wild. These issues are used as a basis to attract local people to become involved in land crab conservation and sustainable development processes focusing on their sustainable livelihoods.

Methodology

In order to answer the question whether land crab management can contribute to conservation and sustainable tourism development in the core zone of a World Biosphere Reserve, various analysis steps were conducted: secondary data is collected using literature review and primary data is collected via Participatory Rural Appraisal.

Literature review

Land crab biological information was collected from secondary data including national and international scientific publications and reports from the MPA Management Board and local governments. Variables subtracted from these articles and reports include topography, geomorphology, vegetation index, humidity, land use patterns and population characteristics to calculate the distribution, yield and population size of land crabs.

Study Area

Cham archipelago located on the East of Quang Nam province, 18 km far from Hoi An city and 15 km far from Cua Dai river mouth. Cham Island constitutes 8 islands: Hon Lao, Hon Tai, Hon Dai, Hon Mo, Hon La, Hon Kho, Hon Cu and Hon Ong. Hon Lao is the largest island and the only island with human habitation: the Cham Islands population of about 3.000 people, constituting 600 households, reside in Tan Hiep commune on Hon Lao. 80% of these households exploit fishery resources as primary source of income [5]. Cham islands marine protected area (MPA) was established for ecological balance, sea environment protection, biodiversity conservation, conservation and development of fishery resources, ecosystem and habitat conservation, and preservation of the long standing cultural and historical value of Cham Island, and protection against negative natural and human impact. The establishment and subsequent actions of Cham Island MPA impacts and impulses socio-economic development and sustainable eco-tourism.

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Currently, the Tan Hiep commune and Hoi An City government implement a strict strategic plan.

Biological diversity of the archipelago is linked to beach, river mouth, nypa palm forest, estuary and the down stream of the Thu Bon river basin for creating a large ecosystem linking corridor. The integration between Hoi An ancient town, a UNESCO world heritage site, and natural resources has shown the special value of the World Biosphere Reserve; the harmonisation of man and nature.

Participatory Rural Appraisal (PRA)

Empirical research for this article was conducted using Participatory Rural Appraisal (PRA). Participatory Rural Appraisal entails methodologies that allow for direct learning from local people in which information is owned and shared by these local people [3]. PRA is a "bottom-up" approach that allows for the collection of data from groups of people that not only incorporates local needs and knowledge but which also allows for decision-making [18].

The methodology used for this PRA includes the DPSIR framework [7] and SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis.

Data was gathered in a workshop during which stakeholder surveys were used for analysis of the current situation and the identification of indicators. Additionally, scenarios were created to present possible solutions and develop an orientation for activities on land crab conservation. The organization of scientific conferences with the participation of national and international experts and the application of local ecological knowledge (LEK) resulted in the creating of indicators for land crab catch monitoring. These indicators include exploitation area, catch time, crab size, eggs carrying status, land crab quota, eco-labeling. The combination of both scientific and local knowledge is used to strengthen the scientific merit of the data as local knowledge in Vietnam is often questioned for its ecological accuracy and trustworthiness [11]. The cost-benefit analysis recipe by Boardman [13] is used to compare and evaluate the effectiveness between traditional management models and the four forces combination model (Government, Scientists, Entrepreneurs and Farmers) in the land crab conservation strategy. An interdisciplinary inspection team including police, executive, farmers union member of Tan Hiep People's committee, MPA staff and communities was established to oversee the catch criteria implementation process and trade activities, and land crab use on Cham Islands.

The present value and investment benefit was calculated by:

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t}$$

And profit ratio was calculated by:

$$BCR = \frac{\sum_{t=0}^{n} \left(\frac{B_t}{(1+r)^t} \right)}{\sum_{t=0}^{n} \left(\frac{C_t}{(1+r)^t} \right)}$$

NPV: Net Present Value; BCR: Benefit Cost Ratio; B_t: Benefit at time t; C_t: Cost at time t.

Results

Land crab resources situation, management, exploitation and conservation.

Analysis shows that in 2000 land crabs were caught on the islands only accidently and were limitedly used for consumption or as gifts for relationships on the mainland. In 2006, the MPA was established and visitors began to come to the islands. As a result, land crab consumption and associated land crab cultivation jobs were created. In 2009, Cham Island became the core zone of the Cu Lao Cham - Hoi An Biosphere Reserve. The number of tourists increased quickly thereby increasing the land crab use demand. Subsequently, the amount of people exploiting land crabs, mining time, frequency, crab size decreased, and exploitation area increased, crab size decreased. Development on Cham Island resulted in the construction of a road circling Hon Lao Island. Both the construction process and the road itself are perceived to impact the ecosystems health in general and in specific the habitat of land crabs; limiting the availability of food for the land crab population on Cham Island.

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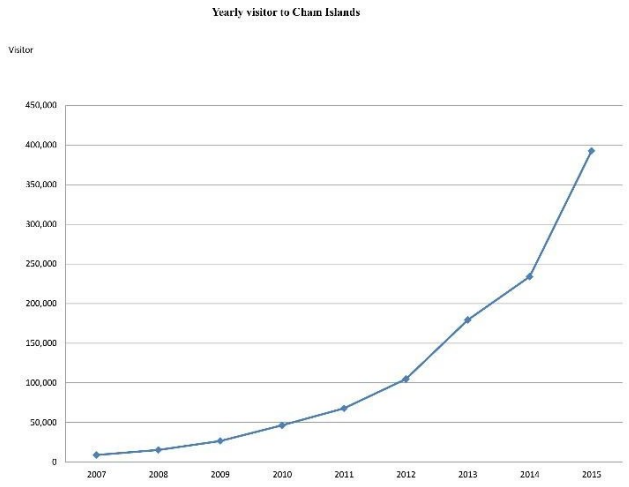
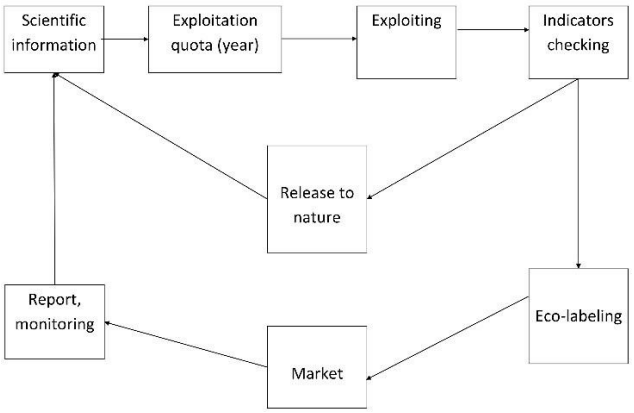


Graph 1: Yearly visitors to the Cham Islands [4]

Figure 4: Visitors on the boat to Cham Islands (Thao. L.N)

Exploitation and consumption activities of land crabs on Cham Island were limited in 2009 by Directive No. 04/2009-CT on September 20 by the Hoi An People's Committee. Analysis shows that this prohibition was not a perfect solution to protect the land crab. As tourism demands continued to rise, people continued to illegally exploit land crabs. Enforcement of this Directive was problematic and ineffective. This resulted in conflicts between community members, tourists, the government and continued until a harmonious balance between exploitation and conservation was suggested by the project "Community participation in natural recovery and conservation of land crab on Cham Islands" by Global Environment Facility (GEF). This project received agreement from the Government and has been implemented as a pilot since 2011.



Graph 2: Land crab exploitation management process in Cham Islands [12].

The management process based on size, time, status, eggs carrying, eco-labeling does not only allow exploitation and local livelihood development; it also supports a natural conservation mission.

DPSIR analysis for conservation and development of land crab populations.

The main results of DPSIR analysis show that urgency is needed for locals and governments to find balance between development and conservation in the implementation of plans.

Driven	The Islands knows a high infrastructural development; Local people increased their forest leaves mining activities.
Pressure	Natural living space has been narrowing and is becoming increasingly fragmented; Nutritional resources are declining; Migration paths are increasingly interrupted by barriers; wildlife decreases.
State	Natural exploitation yields are declining; the average size is decreasing.

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Impact	The ability of natural land crab populations to maintain their population size and income per yield will reduce.
Response	To apply exploitation indicators; to manage people who are exploiting land crabs; to establish the combination of the four forces in land crab management and exploitation.

Table 2: DPSIR analysis results of land crab management process on Cham islands.

SWOT analysis results on land crab population conservation

Strengths	Stakeholder participation for land crab preservationist achieved (*Government, Scientist, Entrepreneur and Community*). Land crab was managed by indicators (*Catching time, crab size, egg carrying status, eco-labelling and Who is allowed to exploit*). Income from land crabs catching is higher than in other sources of income. Subsequently, it has attracted local people to join in land crab conservation implementation.
Weaknesses	Over-exploitation of land crabs in the forest and exploitation in the tidal area when they are carrying eggs is a significant thread. Furthermore, as livelihoods on the island are not diverse - many people are pushed to join the exploitation of the land crab. Conflicts continue to occur with land crab exploitation and tourism growth. Limited attention is given to this issue by the government, conservation agencies and societal actors. Currently the preservation of land crabs for future generations is considered extremely limited.
Opportunities	Cham Islands is one of the few archipelagoes in Vietnam that can keep freshwater and maintain biodiversity for land crab's lives. Land crabs are an indicatory organism, if land crabs are conserved well then all ecosystems, habitats and biodiversity of the islands will also be protected. In addition to defense and security strategies, Cham islands has a very high significance in ensuring social security for about 3,000 people who are living on the islands and for receiving nearly 500,000 tourists each year. There are many research institutes concerned with land crab resources on Cham Islands. They provide supporting scientific information for the local community in land crab conservation strategy.
Threats	Cham Islands has built a lot of infrastructure in recent years such as a road circling the island, electricity cables, sea ports, sea walls and many future projects will be invested in on the islands. This has resulted in a reduction and fragmentation of the natural living space of the land crabs, has affected surface water and groundwater on the islands, and resulted in a decline of the quality and distribution of vegetation surface, cutting off the spawn migration path, and impacted other activities in the land crab lifecycle. Evolution of climate change and harsh living conditions are

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	increasing the negative impact to land crab life's cycle and population.

Table 3: SWOT analysis results of land crab management process on Cham islands.

Establishment and implementation of the land crab exploitation and protection team

The exploitation and protection land crab team was established in 2012 and consisted of 18 members who are professional exploiters. The membership was expanded to 33 members in 2016. The team installed regulations, monthly-yearly quota and the price of land crab. Indicators for land crabs are developed and include size, male/female rate, carrying eggs status, and eco-labeling.

These indicators and the enforcement are the result of cooperation between the farmers union, the Hoi An city government and local people. Furthermore, members also coordinate with the relevant authorities concerning the protection and development of the land crab population in nature.

Creating the land crab catch management indicators

The criteria developed and applied for land crab exploitation on Cham islands are:

(i) Catch, sale, use time allowed: 01st of March to 31st of July.
(ii) The land crab catch quota: based on the current situation of land crab population from scientific information, local people and government agencies discuss and set the land crab catch monthly and yearly quota. The quota is around 10,000 crabs per year since 2012.
(iii) Land crab catch size allowed: Larger than 7 cm of carapace.
(iv) Carrying eggs status: it is not allowed to catch female crabs carrying eggs.
(v) Price: Fixed price is valid for one year.
(vi) Eco-labeling: All legally exploited land crabs are eco-labelled before sale.

Figure 5: Eco-labeling to land crab product (Thao. L.N)

Graph 3: Land crab catching and population rehabilitation phases.

Promoting the four forces combination in land crab catching management process

Although land crab exploitation management processes have been applied, many difficulties and conflicts remain. Enforcement of regulations and controlling exploiters has been shown very difficult to manage. People who are not members of the land crab exploitation team continue to illegally exploit.

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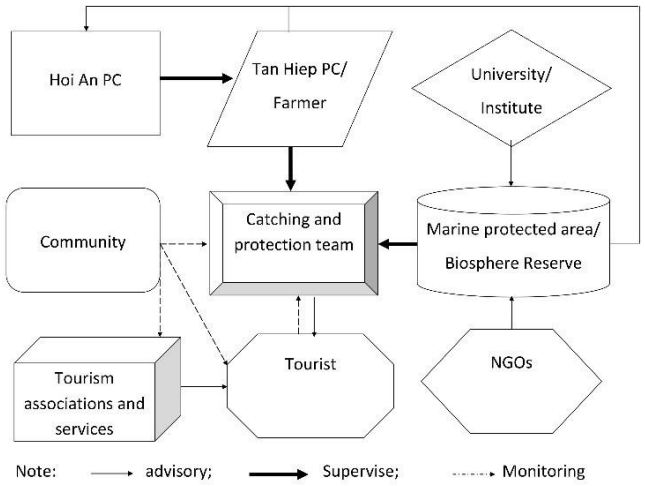
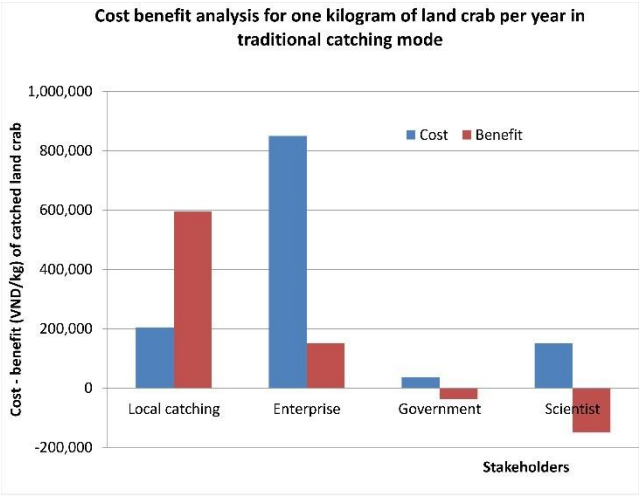


Graph 4: The operational diagrams of four forces cooperation mechanism in land crab management and conservation on Cham Islands [14].



Graph 5: Cost benefit analysis for one kilogram of land crab per year in traditional model [13].

Additionally, members have been reported to transfer eco-labels without the authorities' approval. The activities of the interdisciplinary inspection team are difficult and have been considered inefficient [14]. To resolve these issues the four forces cooperation mechanism for land crab exploitation management processes is proposed. This mechanism comprises the following targets; stakeholder participation, creating coherence and close coordination between stakeholders, creating mutual control between parties, reducing management burdens for authorities, promoting internal resources and strengths of the parties and creating mechanisms to divide responsibilities in managing and reducing risks for resource conservation.

Figure 6: The four forces representatives to participate in land crab co-management program.

The cost of funding to conserve the land crab on the islands amounts to around 1.367 billion Vietnam Dong (VND). This amount is used as a baseline to compare the cost benefit and profit ratio between the traditional model and the 4 forces combination model in land crab management and development process [13].

	Cost	**Benefit**	**CBR[20]**
Traditional mode	1,241,750.00	558,250.00	0.45
4 forces combination	363,700.00	960,000.00	2.64

[20] CBR: Cost Benefit Ratio

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Differences	-878,050.00	401,750.00	2.19

Table 4: Cost – benefit – and CBR comparison [13] Unit: VND

The application of the 4 forces combination in land crab management and development has showed a higher significance in CBR for the whole Cham Island society.

Discussion

Land crabs play a very important role in people's lives on Cham Islands. They are stimulating for tourism development and as biological indicators to monitor the forest ecosystems health. Population size and distribution of land crabs depend on coverage and forest vegetation quality. In the life cycle, land crabs need forests for habitat and food, and tidal areas to spawn. Increasing construction on the islands is impacting the life cycle; making the living space segmented, reducing water resources, decreasing food sources, increasing barriers on the spawning migration path. Currently, the exploitation, sale and use of land crab management at Cham Islands has come into shape. The management is based on scientific information and participation, and ownership is given to the societal partners. However some challenges still persist. To ensure economic development and national security the migration path, eco-region and food resources should be maintained and protected. These issues require the participation of stakeholders to discuss and solve issues in scientific and local practical conditions to improve the land crab population viability. The analysis yielded results on 5 levels: awareness raising, habitat and nutrition preservation, migration path protection, spawning ground protection, human-nature conflict reduction, and the four forces combination effectiveness enhancement.

How to raise stakeholders' awareness on land crab conservation

Understanding on land crabs is a basic necessity for conservation and sustainable development of this resource. The awareness of stakeholders must be raised and exploitation should be linked inextricably to the land crab resource conservation. Analysis reveals that an appropriate program should be designed for each different occupation group.

How to maintain the natural habitat and nutrition resources of land crabs

More and more construction on the island scatters and fragments the eco-region and depletes surface water resources. Additionally, the local forest leave collection for commercial purposes is affecting the distribution and quantity of the vegetation surface - a habitat and food resource for land crabs. The Biosphere Reserve and its stakeholders should reflect on the negative impact from infrastructure construction and increase the implementation process on Environment Impact Access (EIA) for all activities in the islands. Scientific research is needed urgently to find solutions to help land crab overcome physical barriers such as the road around the island to access the tidal area for spawning. Consequently, the current development, the land crab is exploited everywhere: healthy environment, habitat and food for crabs is reduced by decreasing quality and forest cover.

Figure 7: The circling road in the biggest island make barriers for crab spawning path (Thao. L.N).

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The circling road around the island and construction have resulted in fragmented forestation. The road was made as an added advantage for human mobility on the island: thereby reversing the natural distribution of land crab.

In the future, an island should be dedicated with suitable biological and ecological conditions to build an impregnable region (Sanctuary) as a land crab bank for saving land crab genetic resources and other species within the Cham island Biosphere Reserve.

How to solve the interruption of the spawning migration path

In the land crab life cycle, land crabs must move from the forest to the tidal area to spawn. However, the spawning migration path is interrupted by the road circling the island and is preventing access to the water's edge. Conservation agencies and scientists are currently trying to find solutions to protect the spawning migration path for land crab populations on Cham islands. However, no clear solution has been found or implemented and further research is needed.

How to protect the wild land crab spawning grounds

After accessing the waterfront, it is shown that land crabs continue to experience difficulties in tidal areas. There is a significant amount of activities such as snorkeling, scuba diving, fishing, sea embankments within this tidal area. There are too much silhouettes, sounds, lights and human activities in the tidal area which will hinder the spawning of land crab [8]. It is suggested that stakeholders need to discuss additional zoning and dedicate specific areas for the land crab spawning. For this reason Hoi An city has decided that Hon Dai island will be selected to build the land crab sanctuary as a crab bank for future generation.

How to reduce the conflicts between human and nature

Land crab exploitation is managed by the use of indicators. This process is currently being applied and is considered effective. However, habitat, food sources, migratory routes, the number of illegal catch, mining small crabs or catching crab carrying eggs still occurs. The distance between awareness and behavior of land crab cultivators is relatively large. Many weaknesses in management, implementation, operating system and a lack of a mechanism for cooperation between the four forces (government, scientists, entrepreneurs and community) still persists and no clear solutions are currently being implemented. Further research and an increase of the knowledge on management of and by the stakeholders is needed.

How to enhance the effectiveness of four forces combination in land crab conservation

The civilized exploitation managed production with four forces participation has described the process to enhance knowledge exchange, update the condition information and support local communities in the management and conservation process. This is a unique process, which should recognize ownership for the efforts of the community and stakeholders in the conservation and development of natural resources strategy of Cu Lao Cham-Hoi An Biosphere Reserve.

Conclusion

This study highlights that the need to conserve the land crab in conjunction with sustaining local livelihood. A set of criteria/indicators for exploiting and controlling the crab and monitoring team have been set up by agreed stakeholders under the regulation of local Authority. In order to implement effectively the initiative, we argue that the process should be participated by four forces including local government, scientists, entrepreneurs and farmers. Obviously the tourism would be benefits from UNESCO biosphere reserves, but consumption demand from tourists should be responded positively from local governance to meet the harmonizing three functions of biosphere reserves, i.e. conservation, development and logistic support.

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Looking Inward, Looking Outward: Citizen science in the Bras d'Or Lake Biosphere

Annamarie Hatcher, Ph.D. Unama'ki College, Cape Breton University
P.O. Box 5300, 1250 Grand Lake Road, Sydney, N.S., Canada, B1P 6L2

Email: Annamarie_hatcher@cbu.ca

ABSTRACT: The Bras d'Or Lake and watershed is a 3,566 km^2 region of forest, freshwater and marine ecosystems in the centre of Cape Breton Island, Nova Scotia, Canada. The estuary occupies 31% of the Bras d'Or Lake Biosphere and the watershed is thinly populated, with about 6 human residents per square kilometer (2006 census). The evolving Bras d'Or Watch program which is at the nexus of citizen science and public education seeks to strengthen the human-habitat bond among participants by:

1. providing a forum for citizens to interact with their place
2. networking citizens who want to strengthen their bond with place
3. matching residents with scientists and historians who can share their knowledge of place

The Bras d'Or Watch has a diversity of drivers and of anticipated outcomes. In the further development of the program, the goal is to blend ecosystem monitoring and observation based on connection to 'place' to develop an ecosystem-level synopsis (looking inward) which can be used to gauge response to aspects of global climate change (looking outward). Bras d'Or Watch is all about developing the tools to allow us to see and hear what Mother Earth is showing and telling us. This article serves to outline the early development of this program.

Keywords: public education, citizen science, topophilia, ecosystem health, ecosystem monitoring

Introduction

The basic tenets of the UNESCO Man in the Biosphere program (biodiversity conservation, sustainable development and support for education and research) are underpinned by a meaningful connection between the ecosystem and the people that are part of it. The Bras d'Or Lake Biosphere Reserve is a unique estuarine system immersed in strong and vibrant Mi'kmaw, Gaelic and Acadian cultures. Each of these cultures is deeply connected to this place. However, the current climate of global warming is causing change at an uncomfortably rapid place and a more frequent re-acquaintance with 'place' is a strategy to reinforce the basic tenets. To accomplish this goal, the Bras d'Or Lake Biosphere Reserve Association has launched a program called 'Bras d'Or Watch'. This program is developing partly as an outreach activity and partly as a vehicle for citizens and visitors to accurately observe change in the ecosystem using an annual 'report card' approach. This article outlines the early development of the program on a small budget with an army of committed volunteers.

The Bras d'Or Lake Biosphere

The Bras d'Or Lake and watershed is a 3,566 km^2 region of forest, freshwater and marine ecosystems in the centre of Cape Breton Island, Nova Scotia, Canada. The estuary occupies 1,109 km^2 (31 percent) of the area, with the rest of the 2,474 km^2 constituting the watershed (catchment area). According to the 2006 census, the Biosphere is home to 14,579 human inhabitants. Although there is no reliable record of the summer population residing along the Lake, the estimated number of summer residences is in the range of 2,000. The length of the coastline of the Lake is approximately 1,230 km. The two largest settlements in the area of the Bras d'Or Lake Biosphere Reserve are the town of Baddeck and the Mi'kmaw community of Eskasoni. Mi'kmaq were the first peoples of the Bras d'Or Lake Biosphere and the largest community is nestled on the shores of the estuary (Eskasoni). The population of the four Mi'kmaw communities within the Biosphere was 4,240 in the 2006 census, and the population is growing rapidly. The watershed includes a number of small towns, mainly along the coast of the

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Lake, with populations of several hundred each. Many of these communities are quite insular and have little interaction with other communities. Cultural histories are vibrant, with Gaelic, Acadian and Mi'kmaw identities often defining geographic boundaries.

On July 1, 2011 the Bras d' Or Lake received UNESCO Biosphere designation as Canada's 16th Biosphere Reserve. The designation of the Bras d' Or Lake as a UNESCO Biosphere Reserve site is the result of a highly collaborative process that started in 2005 involving First Nations representatives, Federal and provincial agencies, academics and nearly fourteen thousand (14,000) citizens in the region. The focus of the UNESCO Mab in the Biosphere program is about balancing the needs of people with the needs of the environment. The pillars of the program are conservation, sustainable economic development and capacity building through education and research. This umbrella unites a community of practice (Bras d'Or Watch) in the Bras d'Or Lake Biosphere Reserve which is composed of people and organizations that would normally have little interaction. Organizations that have contributed volunteers and equipment for the developing Bras d'Or Watch include government (Cape Breton Regional Municipality, Richmond County), post-secondary institutions (Cape Breton University), Mi'kmaw organizations (Eskasoni Fish and Wildlife Commission, the Unama'ki Institute of Natural Resources), ACAP Cape Breton (Centre for Sustainable Communities), and other small businesses and community groups (Baddeck boatyard, Ben Eoin RV Park, Aros Na Mara, Grand Narrows Waterfront Redevelopment Society). One of the goals of the evolving Bras d'Or Watch is to forge a connection among communities under the common umbrella of learning about the ecosystem that they all share. In the process of this exercise, we hope to learn more about each other. The sites for the initial Bras d'Or Watch are positioned in the location map in **Figure 1**.

Looking inward: Connecting to 'place'

It has been recognized in many fora that there is a basic human need to connect with their natural surroundings. The association between people and their place has been called 'topophilia,' a term coined in 1947 by W.H. Auden, a poet (Mendelson, 2002). This could be viewed as human-habitat bonding. Over evolutionary time, humans have been successful amidst periods of significant environmental upheaval because of their adaptation to place. Late Pleistocene hunter-gatherers did not depend on ecological domination to successfully colonize the globe, as has been commonly proposed. Instead, they were probably successful because of place-based cultural evolution (Sampson, 2012). The term 'endemophilia' has been coined to describe a person's immersion in the locally distinctive elements of place (Albrecht, 2012) and it is a relationship that can influence mental health. The evolving Bras d'Or Watch program seeks to strengthen the human-habitat bond among participants by:

1. providing a forum for citizens to interact with their place
2. networking citizens who want to strengthen their bond with place
3. matching residents with scientists and historians who can share their knowledge of place

Looking outward: Ecosystem health and 'place'

Is the Bras d'Or Lake Biosphere 'healthy'? During the initial Bras d'Or Watch field days, many participants asked that question. There are two distinct paths to develop a report card on an ecosystem that enables a synoptic assessment of ecosystem health. The first is through rigorous, objective data collection by trained scientists using specialized equipment. Ideally, accurate data collected throughout this process is statistically summarized and presented in a standard format with publication in peer-reviewed international journals usually categorized by discipline. The second path is through an examination of LEK (local ecological knowledge) or TEK (traditional ecological knowledge) which involves less clearly defined methods of data collection underlain by a deep connection of humans with their natural surroundings. The summarization of data during this process is more personal, relying on the sensory inputs, cultural knowledge and memory of the observer. It is this path that we follow when we decide where and when to go fishing in the spring or to gather wild food such as fiddleheads and blueberries. It is this path that encompasses the wealth of knowledge referred to as TEK and in the Bras d'Or Lake Biosphere MEK 'Mi'kmaw Ecological Knowledge'. In the further

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development of Bras d'Or Watch, the goal is to blend the two paths to develop an ecosystem-level synopsis (looking inward) which can be used to gauge response to aspects of global climate change (looking outward). This is not a simple task.

One Thousand Eyes: Nature as an architect of science learning

The initial development of Bras d'Or Watch was inspired by an early program in Nova Scotian schools called 'One Thousand Eyes'. Guiding a connection of people to place seems like a modern need, fueled by the obsessive connection between humans and electronic devices. Long before the invention of the cell phone, this need to connect with nature fueled an inspirational program launched in the early twentieth century in Nova Scotia by an educator named Alexander Howard MacKay. MacKay was born in 1848 in Plainfield, Nova Scotia. In 1891 he began a 35-year term as superintendent of education for Nova Scotia and during that time he instituted a program of phenological observation for rural schoolchildren (Guildford, 2003). This program required students to note the first appearance of botanical phenomena during the year and to provide the information to the teacher. This program, called 'One Thousand Eyes' nurtured close ties to place in thousands of schoolchildren across the province. The role of nature as the architect of science learning rather than a constructed laboratory was in direct contrast to the current ways of thinking in education at that time. The Nova Scotia Museum of Natural History holds MacKay's collection of these reports from 1898 to 1923. The database was recognized in the 1990s as a globally-significant benchmark for assessing climate change" (Fenech, 2005; Zwarenstein, 2010, Zeller, 2015). How could we develop a similar program in the Bras d'Or Lake Biosphere? The observers are not captive school children but interested people of all ages and backgrounds. The co-ordinators are not trained school teachers but a committed group of engaged local community leaders and post-secondary students. As a result, the ongoing development process is fluid and organic at the nexus of citizen science and public education.

Citizen Science

The participants in Bras d'Or Watch are citizen scientists. Citizen science is an effective approach to learn about the environment because it often includes specific and measurable goals to focus on (Reynolds and Lowman, 2013). Citizen science can be defined as the involvement of citizens from the nonscientific community in academic research and monitoring (Trumbull et al. 2000, Lee et al. 2006). It is a field that is undergoing rapid growth worldwide. It has been determined, based on many citizen science programs that success is built upon: (1) a simple monitoring system; (2) adequate training of volunteers and participants; and (3) providing all volunteers with timely feedback on their work. These requirements underpin the Bras d'Or Watch program. Many studies have shown that an increased involvement in stewardship and conservation activities result when volunteers are engaged in a citizen-based monitoring or research program. This may be a genuine revolution in 'science' that democratizes the important social role of learning about our natural world **(***Working Group Synthesis Report www.citizenscience.org/conference; Citizen Science Toolkit Conference June 20th-23rd, 2007, Ithaca, NY***)**

Bras d'Or Watch: Citizen Science or Outreach?

Originally the stated goal of Bras d'Or Watch was to set up a network of engaged citizen who would monitor basic estuarine properties such as salinity and temperature in waters surrounding their own back yards. An inaugural field day was set up for July 16, 2015 and six sites were chosen with the aim of taking measurements simultaneously with broad geographic coverage. To provide opportunities for a wide range of participants, several data collection and identification sheets were prepared which ranged from counting targeted invasive species (**Figure 2**) to providing a summary of nearshore water salinity and temperatures (**Figure 3**). All data collection was to take place in shallow inshore waters or on the adjacent beach and headland areas. The sites in the Bras d'Or estuary were in East Bay, Eskasoni, St. Peter's, Whycocomagh, Grand Narrows and Baddeck, which are up to 50 km apart by road. Local communities hosted the event and scientists and students from Cape Breton University, ACAP Cape Breton (Centre for Sustainable Communities) or within the Bras d'Or Lake Biosphere Reserve Association were recruited to supervise each of the sites. The local papers and radio stations publicized the event and many people participated **(Figure 4)**. Data was collected and a synopsis produced and published in the local newspaper (**Figure**

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5). More importantly, neighbours shared a mutual interest in learning about their place.

The Bras d'Or Watch field day is equivalent to speed dating. Acquaintances are made and connections among people and environment strengthened. A core group returned for Bras d'Or Watch field day on July 17, 2016 but participation dropped considerably from the previous year. This led to reflection about the goals of the program. Is the main goal the collection of accurate scientific data? Are we defining a goal related to accurate monitoring or to educational outreach, or both? Connecting an army of citizen scientists across the large distances in this Biosphere required an enhancement of the outreach. Participants who were engaged in 2015 did not return in 2016 because they had 'already done that'. The current evolution of the program is guided by the passions of the volunteers and feedback from participants with an eye toward the constraints imposed by the large size of the Biosphere and the long distances between communities.

Evolution and Devolution of Bras d'Or Watch

Based on the experience during the two Bras d'Or Watch field days, stakeholders have defined the ways forward for this developing program. Bras d'Or Watch is now splitting into three related but separate components. The **Field Day (Blitz)** is aimed at public education and celebration of the ecosystem. This is a coming together of interested people who want to learn more about the ecosystem in a social setting. It provides a focus for public education and an incentive for citizen engagement. Each summer we will present a different theme (ie: bird surveys, alien species spotting etc.). The primary goal is not data collection although many observations may be used in the compilation of the report card. The second component for this Bras d'Or Watch program is **Monitoring** (scientifically-defensible data to be submitted and analyzed). These data will form the core of the report card. To achieve broader geographic and seasonal coverage, interested citizen monitors emerge around the field day. This type of engagement was noted during the first two field days. Those citizen monitors were often people who own property on or near the shore and are interested in keeping in closer touch with their immediate surroundings. They travelled to one (or more) of the six Bras d'Or Watch field sites to find about the project. In the evolving Bras d'Or Watch, these volunteers will be armed with equipment, instruction and a portal to submit data at any time. We will enable a similar sort of engagement between school groups and their nearby shores. Equipping these citizens and school groups with equipment and information on the significance of their efforts encourages human-habitatbonding. School groups can participate with a trained teacher at the teacher's convenience. The information packages will also engage residents and visitors to watch for 'sentinels', or invasive species such as the European green crab and the Asian shore crab. The third component for the evolving Bras d'Or Watch program will be a self-contained **Package for community groups**. These will be based on scavenger hunts and other light- hearted learning experiences. With the assistance of summer students, these exercises will be incorporated into community festivals.

Citizen-based monitoring: Accurate data for robust conclusions?

Maintaining interest and enthusiasm among citizen scientists to ensure data continuity and accuracy is necessary and challenging. Rapid and meaningful feedback is essential. Many citizen science projects have failed because volunteers feel that their input is flowing into an abyss from which it will never surface. The process of data collection and compilation from volunteers needs to be planned from the outset. When data are submitted digitally, this process is easy. Reports are almost instantaneous and available to stakeholders. This will be one route of many for the evolving Bras d'Or Watch. However, the network of neighbours will continue to meet in person and indulge in a less directed communication with their environment.

There have been many studies analyzing the accuracy of citizen-collected data (Shelton, 2013). Some environmental variables require a trained scientist. Dissolved oxygen is an example of a variable which can be problematic. Many environmental factors influence the concentration of dissolved oxygen so a trained eye is required to ensure representative sampling. In the Bras d'Or Watch program, the monitoring variables have been carefully chosen with regards to this concern. Temperature, pH and salinity are the core water measurements. These can be accurately taken by citizen scientists (Shelton, 2013) and are very informative. For example, water

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temperature is one of the primary criteria used by governments to define habitat requirements for fish species, guiding habitat protection measures (Shelton, 2013 ; Plumb & Blanchfield, 2009).

Where to from here?

Based on feedback from citizens and educators in the Bras d'Or Lake Biosphere, new branches of the Bras d'Or Watch tree are sprouting. New initiatives that we will develop include an extension into the watershed forests with established monitoring protocols and a Secchi disc program in partnership with local marinas. A large diversity of types of forest monitoring programs are well-established in many other areas and protocols are available and robust. The Secchi disc is a device which is widely used by citizen scientists, environmental consultants and oceanographers. It is a visible disc that is lowered over the side of a boat. The depth of disappearance is directly related to water clarity. It is an inexpensive way to develop a powerful diagnostic which has been related to events such as erosion and runoff, sewage inputs and spring algal blooms. These programs will develop in parallel to the shore-based activities and all will contribute to the deepening relationship between the Bras d'Or Lake Biosphere and its' people.

Summary and Conclusions

Bras d'Or Watch is at nexus of citizen science and public education, representative of a genuine revolution in 'science' that democratizes the important social role of learning about our natural world. One of the goals of the evolving Bras d'Or Watch is to forge a connection among communities under the common umbrella of learning about the ecosystem that they all share. The multidimensional approach to summarize input and provide feedback is the 'report card'. This approach includes two paths of knowledge: scientifically-defensible data collection and LEK/ TEK (local and traditional ecological knowledge). Scientifically-defensible data can be collected electronically with high temporal and spatial coverage. Developing the lens to filter LEK is a more difficult process, requiring an orchestrated dance among researchers, residents, students and visitors. The incorporation of TEK is also challenging as it is a living knowledge embedded in culture and tradition and not necessarily parallel to the scientifically-defensible data or LEK. The ultimate goal of Bras d'Or Watch is to engage all of these knowledges, enable a deeper engagement with ecosystem, and to develop the tools to allow us to see and hear what Mother Earth is showing and telling us

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Figure List

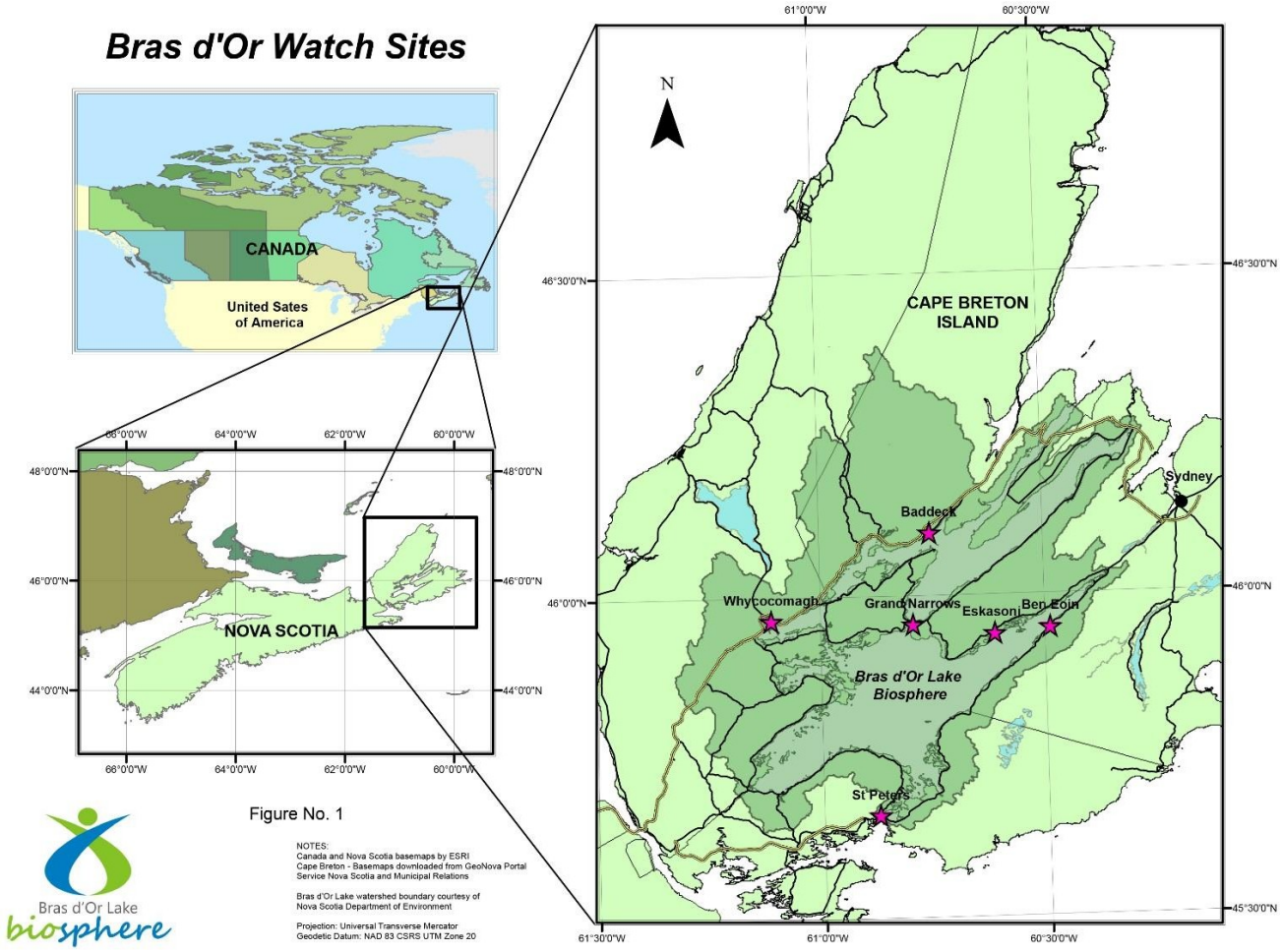

Figure 1: Bras d'Or Watch Sites

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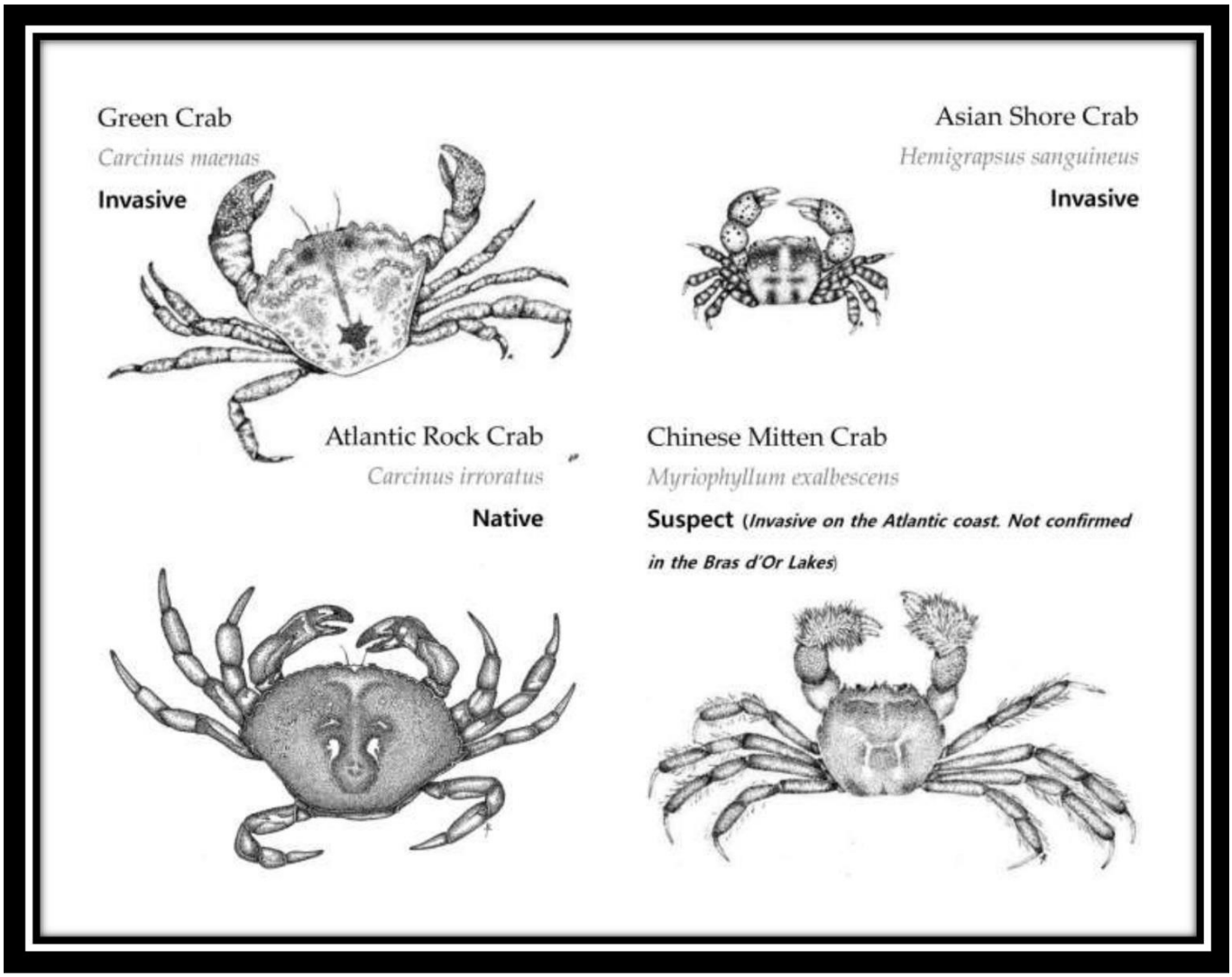

Figure 2: ID sheet for Bras d'Or Watch participants showing two species of resident crabs and two species that are of special concern. Figures drafted by Jen Cooper.

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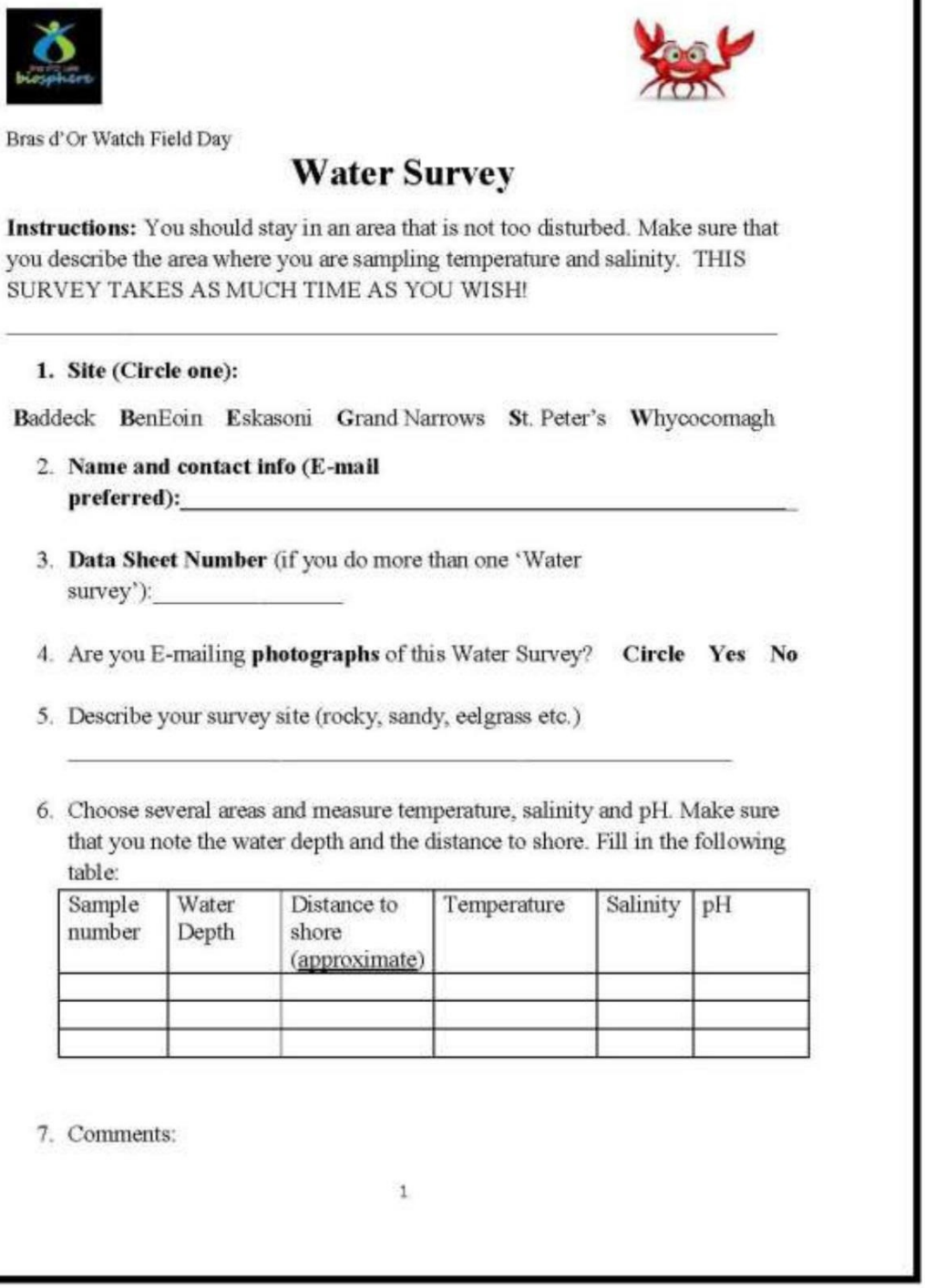

Bras d'Or Watch Field Day

Water Survey

Instructions: You should stay in an area that is not too disturbed. Make sure that you describe the area where you are sampling temperature and salinity. THIS SURVEY TAKES AS MUCH TIME AS YOU WISH!

1. **Site (Circle one):**

Baddeck **B**enEoin **E**skasoni **G**rand Narrows **S**t. Peter's **W**hycocomagh

2. **Name and contact info (E-mail preferred):**_____

3. **Data Sheet Number** (if you do more than one 'Water survey'):_____

4. Are you E-mailing **photographs** of this Water Survey? **Circle Yes No**

5. Describe your survey site (rocky, sandy, eelgrass etc.)

_____

6. Choose several areas and measure temperature, salinity and pH. Make sure that you note the water depth and the distance to shore. Fill in the following table:

Sample number	Water Depth	Distance to shore (approximate)	Temperature	Salinity	pH

7. Comments:

1

Figure 3: Example of a data sheet that was filled out by Bras d'Or Watch Field Day participants

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Figure 4: Young participants in Bras d'Or Watch Field Day 2016

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CAPE BRETON POST

Cape Breton Post > News > Local

Inaugural Bras d'Or Watch field day a success

Laura Jean Grant
Published on July 20, 2015

SYDNEY — People of all ages were lakeside Saturday afternoon exploring and learning about the Bras d'Or Lake.

Kaitlyn Cann, from left, Laura Holden and Jen Cooper were three of the biologists who helped out with Bras d'Or Watch Field Day activities at Ben Eoin Beach Campground.

The inaugural Bras d'Or Watch Field Day was held Saturday afternoon at six sites on the island and drew approximately 175 participants.

"We're certainly pleased with the turnout," said Annamarie Hatcher, chair of the Bras d'Or Watch committee. "I think it was a very positive first step and the people who came, most of them were really committed to learning."

Hatcher said it was really nice to see the enthusiasm of participants as they took part in a variety of activities aimed at educating them about Bras d'Or Lake and its ecosystem

Activities at the six Bras d'Or Watch sites — Baddeck, Ben Eoin, Grand Narrows, Eskasoni, St. Peter's and Whycocomagh — varied Saturday and included people taking part in bird watching, walks, diving, ecosystem surveying, beach seining, and wading into the water looking for crabs and fish.

Figure 5: Excerpt from 'Cape Breton Post' after the inaugural Bras d'Or Watch field day.

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UNESCO Biosphere Reserve management evaluation: where do we stand and what's next?

Diane A. Matar, PhD Department of Environmental Sciences and Policy, Central European University
Nádor u.9, 1051 Budapest.

Email: matar.adiane@gmail.com.

Brandon P. Anthony, PhD, Associate Professor Department of Environmental Sciences and Policy, Central European University
Nádor u.9, 1051 Budapest.

ABSTRACT: This article provides the first comprehensive review of the discourse evolution of UNESCO Biosphere Reserve evaluation, relative to the general discourse of Protected Area Management Effectiveness (PAME) evaluation. Using literature review and content analysis, it addresses two main research questions: (1) In light of recent literature, is it still relevant and important to evaluate protected areas and biosphere reserves? (2) To what extent has the Periodic Review (PR), which is the only performance evaluation required by the UNESCO Man and the Biosphere programme, effectively addressed the need for "standard indicators to evaluate the economic, social, and ecological progress made by biosphere reserves" (IUCN 1995)? Using synthetic argumentation, we find first that management effectiveness evaluation is still highly relevant and essential for the effective management and global expansion of protected areas and biosphere reserves networks. Second, the PR report has been a soft evaluation tool that led to improved implementation of the biosphere reserve concept, by tackling mainly the *design* and *planning* aspects. However, it lacks results-based indicators that specifically measure *delivery of objectives* linked to the three functions of biosphere reserves (conservation, sustainable development, and logistic support). Third, the PR tool is not designed to systematically integrate into an adaptive management cycle recommended for biosphere reserves. Drawing from lessons and advancements made in PAME evaluation, we conclude with targeted recommendations for the improvement of biosphere reserve management evaluation, in the perspective of enhancing their contribution to the global sustainable development goals.

Keywords: Biosphere reserve, periodic review, UNESCO, protected area, Management effectiveness evaluation

Introduction

The UNESCO World Network of Biosphere Reserves (WNBR) is an international intergovernmental programme initiated in 1971 to reconcile conservation with sustainable development. Initially overlapping with conservation sites designated and legally protected nationally, the Biosphere Reserve (BR) concept gradually improved the implementation of its model by enhancing implementation of its zonation scheme and integrated functions (Ishwaran et al., 2008; Price et al., 2010). Its design currently consists of core, buffer and transition zones, serving three main functions: (1) conservation of natural and cultural values, (2) logistic support for education, training, research and monitoring (3) and sustainable development (UNESCO, 2016a). However, one important component remained largely neglected.

By 1995, when the network had grown to 324 sites in 82 countries, the International Union for the Conservation of Nature (IUCN) - in its *Evaluation of the Implementation of the 1984 Action Plan for Biosphere Reserves*, highlighted that BRs had "no built-in way of evaluating performance and no standardized measure with which to evaluate the economic, social, and ecological progress made. Consequently, it [was] difficult to identify what constitutes 'successful' implementation as a whole" (IUCN, 1995, p. i). More than twenty years following this IUCN observation, we discuss how this evaluation gap has been addressed, and what remains unresolved.

This review sheds light on the following questions:

- How relevant is this problem today, in light of new evidence from the general Protected Areas

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(PA) effectiveness literature, and parallel evolution of the Protected Areas Management Effectiveness (PAME) evaluation discourse? In other words, is it still relevant and important to evaluate PAs and BRs?

- To what extent has the performance evaluation required by the UNESCO Man and the Biosphere (MAB) programme - i.e. the Periodic Review (PR) report, effectively addressed the identified need for a "standardized measure with which to evaluate the economic, social, and ecological progress made" [by biosphere reserves]? (IUCN, 1995)?

Based on literature review of peer-reviewed publications (pertaining to PAME and BR evaluation) and UNESCO official documents, as well as content analysis of the PR forms and PAME methodologies, we use synthetic argumentation to provide evidence that:

- PAME evaluation is still very relevant and essential to decision-making for effective management of existing PAs and BRs, and for the expansion of both networks.
- The PR report has been a generally soft evaluation tool that triggered positive changes for improved implementation of the BR concept mainly in terms of design and planning for the three functions.
- The PR qualitatively evaluates concept implementation but is not designed to measure the effectiveness of BRs in fulfilling their functions, due primarily to the absence of indicators that specifically measure outcomes related to the three functions.
- Though adaptive management is recommended for BR management effectiveness, the PR tool is not designed to systematically integrate into an adaptive management cycle for BRs.

Based on this review, we argue that 20 years after the IUCN evaluation of the MAB programme's action plan, the need for a "standardized measure with which to evaluate economic, social, and ecological progress made" persists. It is essential to tackle this gap for the WNBR to effectively fulfil its new strategic directions, including serving as an effective instrument for the fulfilment of the world's Sustainable Development Goals (UNESCO, 2015). Drawing from the lessons and advancements made in the evaluation of PAs, this review concludes with a number of targeted recommendations for the enhancement of BR Management Effectiveness Evaluation (MEE).

Biosphere reserves in the general protected area system

Protected areas and other international programmes

Protected areas are considered the key global strategy for the conservation of species populations and habitats (Geldmann et al., 2013; UNEP - WCMC & IUCN, 2016). Their number has been continuously rising, and is currently estimated at 217 155 in 244 countries (excluding UNESCO BRs) covering 14.7 percent of terrestrial regions and 10.1 percent of marine areas within national jurisdictions (UNEP - WCMC & IUCN, 2016). In parallel, other models of site protection under international programmes with a conservation focus or component have been flourishing, all of which aim to contribute to the global sustainability agenda (Schaaf & Clamote Rodrigues, 2016). Designations under these international programmes include: (i) World Heritage Sites estimated at 1052 properties (238 natural or mixed sites) in 165 states (UNESCO World Heritage Center, 2016), (ii) UNESCO BRs organized into a network of 669 in 120 countries (UNESCO, 2016a), (iii) UNESCO Global Geoparks estimated at 120 in 33 countries (UNESCO, 2016b), and (iv) 2261 Ramsar sites in 169 countries (Ramsar Convention Secretariat, 2016). These international designations often overlap with nationally designated PAs, and sometimes with each other, creating Multi-Internationally Designated Areas (Schaaf & Clamote Rodrigues, 2016). Though the multitude of designations on the same surface of land or sea emphasizes the importance of these sites for their natural and cultural values, their management and evaluation become more complex due to the several layers of governance and institutional requirements that are often not proactively aligned (Schaaf & Clamote Rodrigues, 2016). Here, we focus on BRs, of which the design typically comprises core zones that overlap with nationally designated PAs (Dudley, 2013; UNEP - WCMC & IUCN, 2016); therefore, we revisit these two concepts' definitions.

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Protected area definition

The most widely adopted definition of a PA is the one updated in 2008 by the IUCN: "a clearly defined geographical space recognized, dedicated and managed, through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008, p. 8). This definition revised the IUCN (1994) version by introducing the aspect of ecosystem services, and highlighting objective-based management. Another popular definition of a PA was developed by the Convention on Biological Diversity (CBD), hence recognized by all 196 parties of the Convention: "a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives" (CBD, 2016).

Biosphere reserve definition

Since its inception, the BR concept has gradually evolved from a conservation focus toward a higher degree of integration of the human element and related sustainable development activities (Ishwaran et al., 2008; Price et al., 2010). Early in the MAB programme, a BR was essentially designated through identifying existing sites of high biodiversity value(s) (Ishwaran et al., 2008). This is reflected in UNESCO's early definition of BRs as "protected areas of representative terrestrial and coastal environments which have been internationally recognized for their value in conservation and in providing the scientific knowledge, skill and human values to support sustainable development" (UNESCO, 1984). However the BR concept has gone through many iterations as it adapted to evolving strategic directions of the MAB programme, which are attuned to global sustainability agendas (Millennium Development Goals, Global Sustainable Development Goals) (UNESCO, 2016a). Chronologically, three main phases can be distinguished in the evolution of the programme, which are marked by two milestone events: (1) the Seville conference in 1995, resulting in *The Seville Strategy & The Statutory Framework of the World Network* (UNESCO, 1996), and (2) the Madrid meeting in 2008 resulting in the *Madrid Action Plan* (MAP). These outputs constitute to date the main governing documents of the MAB programme of work. A fourth phase has now been launched with the adoption of the *2015-2025 MAB Strategy*, which highlights more explicitly the instrumental role of BRs in contributing to the achievement of the 2015-2030 Sustainable Development Goals (UNESCO, 2015). In light of the complex evolution of the MAB programme, BRs have now reached a more sophisticated definition:

Biosphere reserves are areas comprising terrestrial, marine and coastal ecosystems. Each reserve promotes solutions reconciling the conservation of biodiversity with its sustainable use.

Biosphere reserves are Science for Sustainability support sites – special places for testing interdisciplinary approaches to understanding and managing changes and interactions between social and ecological systems, including conflict prevention and management of biodiversity. (UNESCO, 2016a).

Throughout the conceptual developments of the BR, its design remained essentially the same since 1983 when the designation 'transition zone' was introduced to replace 'outer buffer zone' (Price et al., 2010). The BR design consists of a three-zone scheme with a legally protected core zone (also called core area) dedicated to conservation of biodiversity, surrounded by a buffer zone that focuses on the logistic function for research, education and training while accommodating a limited level of resource use and human activity, and an outer transition zone (also called 'area of cooperation') incorporating more human settlements and sustainable socio-economic development activities (e.g. eco-tourism, agriculture) (UNESCO, 2016a). Buffer and transition zones do not need to be legally protected. Few noticeable adaptations to the structure were made with time, including (1) allowing for the designation of several core areas; (2) requiring boundary delineation of the transition zone; and (3) a larger integration of the zones' functions. The latter meaning that conservation, sustainable development, and logistic support, can be implemented in all zones but with varying degrees, depending on the functional focus of each zone (Matar, 2015; UNESCO, 1996). Finally, though the BR is an international designation, the sites have always stayed under the jurisdiction of their States.

The UNESCO biosphere reserve in the IUCN protected area categories system

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The IUCN classifies PAs in different categories based on their management objective(s) (Dudley, 2008). Of the international designations, Biosphere Reserve and World Heritage Site were originally identified as categories in their own right, unlike Ramsar sites (Dudley, 2008). However, the 1994 IUCN guidelines report and its updated version (2008) excluded international designations from the standard categories (Dudley, 2008). The overlapping coverage of BRs and PAs combined with the exclusion of BRs from the formalized PA classification is believed to be the root cause for the conceptual confusion that led to the publishing of a manual in 1996 focusing on clarifying the differences between PAs and BRs (Bridgewater et al., 1996). The main message of the manual was that the two models are not contradictory nor mutually exclusive, rather PA categorization can enhance the implementation of BRs. The authors explain that IUCN categories are based on management objectives, and therefore BRs cannot fit into only one category since their basic premise is inclusive of multi-management purposes within the functional zonation scheme. Hence the different zones may be aligned with different PA categories depending on their management objectives. They argue that the IUCN categorization system provides a good framework to develop BR management plans that recognize the zones as PAs with different management objectives (Bridgewater et al., 1996).

Despite the close link between BRs and PAs, the governing institutions supporting and administering the two programmes internationally i.e. UNESCO-MAB Secretariat and the IUCN Global PA programme respectively - have no formal arrangement to align and synergize their management and operations at the implementation level (Matar, 2015; Schaaf & Clamote Rodrigues, 2016). Moreover, their evaluations are decoupled processes despite their superimposition.

Protected Areas Management Effectiveness (PAME) evaluation: discourse evolution

PAME evaluation as a requirement

The worldwide proliferation in number and coverage of PAs and other internationally designated sites did not yet lead to reaching biodiversity conservation goals as global indicators continue to reflect a persisting decline in species numbers and habitats (2010 BIP, 2010; WWF, 2016). The ambitious 2010 conservation targets set by the CBD were not met; in response, the Parties to the Convention adopted a more rigorous plan for 2020 (CBD, 2012). Lack of effectiveness of PAs has been increasingly highlighted as one of the main reasons behind failure to halt biodiversity loss (Anthony, 2014; Cantú-Salazar & Gaston, 2010; Juffe-Bignoli et al., 2014; Leverington et al., 2010a, 2010b). In that perspective, PAME evaluation has become a priority measure toward achieving the 2020 global targets for PAs and biodiversity, as highlighted in the 2014 Protected Planet report: "Assessing whether protected areas are being effectively managed is a crucial element of Aichi Biodiversity Target 11, and a vital prerequisite for achieving protected area objectives" (Juffe-Bignoli et al., 2014, p. 25).

Since biodiversity outcomes are influenced by several characteristics - including the social and economic contexts of PAs, and the relevance of indicators- the relationship of PAME results with conservation outcomes is not straightforward (Anthony & Shestackova, 2015; Carranza et al., 2014; Juffe-Bignoli et al., 2014; UNEP - WCMC & IUCN, 2016). However, recent evidence has consolidated the persistent global importance of PAs as a strategy for conservation, by demonstrating significantly higher species richness and abundance inside than outside PAs (Gray et al., 2016). In their global study, Gray and colleagues (2016) also highlighted the very high cost (including opportunity cost) associated with PA expansion, and subsequently emphasized the critical importance of quantifying the effectiveness of PAs to justify their maintenance and expansion.

At the level of policy, the increase in focus on the management effectiveness aspect of PAs was translated into stricter requirements by the CBD (2010). Indeed, the requirement for CBD parties to conduct and report PAME evaluations for 30 percent of areas covered by PAs nationally was doubled to 60 percent for the 2010-2015 period (CBD, 2010). In summary, the need to evaluate and quantify effectiveness of PAs - and other international sites - in achieving the goals they were designated for, remains a very contemporary and germane topic. Therefore, if not properly conducted, more efforts need to be invested in improving evaluation.

PAME evaluation tools

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PAME has been defined by Hockings and colleagues (2006, p. xiii) as a reflection of (i) design relating to both individual sites and PA systems; (ii) adequacy and appropriateness of management systems and processes; and (iii) delivery of PA objectives including conservation of values. On the other hand, MEE has been defined as "the assessment of how well the PA is being managed - primarily the extent to which it is protecting values and achieving goals and objectives" (Hockings et al., 2006, p. xiii). Building on these background definitions and empirical evidence, international experts have developed a plethora of MEE tools based on the WCPA Framework created by a special taskforce from the IUCN - World Commission on Protected Areas (WCPA) (Hockings, 2003; Hockings et al., 2000). These MEE tools were improved with time, and gradually adopted by many organizations worldwide such as the World Wide Fund for Nature - World Bank (WWF - WB) Alliance, and were adapted to different management objectives of PAs (Hockings et al., 2006; Leverington et al., 2008, 2010a). The discourse on PAME evaluation has evolved with the leadership of the IUCN-WCPA taskforce that continuously updates the Framework and reports on practical experiences (Hockings et al., 2006).

PAME evaluation implementation and reporting

In 2010, experts collected and compiled accessible PAME evaluation reports from around the world and recorded more than 50 methodologies developed mainly based on the WCPA Framework (Leverington et al., 2010b). Through a project led by the WCPA and UNEP - WCMC, a Global Database of PAME evaluation reports (GD-PAME) was created to collate collected reports, and continues to be populated online (Coad et al., 2015; Leverington et al., 2010a), therefore increasing transparency of PA reporting and performance. As of 2015, the GD-PAME contained 17 739 reports for 9037 PAs, using more than 90 different evaluation methods (Coad et al., 2015).

Despite these global efforts toward measuring PAME, reports compiled in 2010 showed that only 22 percent of PAs have a "sound management" (Leverington et al., 2010b). Moreover, a 2013 appraisal demonstrated that only 29 percent of PAs had completed and reported the required MEEs; 90 countries (of 196 parties reporting to the Convention) had reached the 30 percent CBD target of 2010, and only 45 had achieved the 60 percent target of 2015 (Juffe-Bignoli et al., 2014). This wide gap between the policy requirement and implementation reflects the persisting need to expand and institutionalize PA MEE worldwide.

Notwithstanding the imperfect nature of PAME evaluation tools and processes, many important lessons have been gained from international experience. What we have learnt from the PAME experience (Leverington et al., 2010a; Pomeroy et al., 2014) is that evaluation should be:

(1) useful to managers and stakeholders and relevant to improving management,

(2) practical in use and cost,

(3) inclusive of scientific input and stakeholder participation,

(4) flexible for use in varying sites and conditions,

(5) systematic and part of an effective management cycle, and

(6) based on holistic indicators balancing human and natural perspectives.

These lessons from PAME evaluation are also relevant to the BR evaluation as will be developed later in this review. However, we first explore how the BR evaluation is doing to date, and what are some of its main characteristics and challenges.

Evaluation of biosphere reserves: progress relative to the general discourse

Relative to PAME evaluation efforts, the UNESCO-MAB experience in evaluation has been slower and less rigorous (Price et al., 2010; UNESCO, 1996). Until recently, there was no process for identifying "unsatisfactory concept implementation or management" of BRs (UNESCO, 1996). The PR report was only introduced 22 years after the first BR was designated i.e. in 1996, during the Seville meeting, and remains the sole evaluation tool officially required from BRs to be submitted after ten years of designation, and every decade thereafter (UNESCO, 1996). Generally, the PR has proven to be a soft tool receiving a low response rate and in

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need of improvement (Lotze-Campen et al., 2008; Matar, 2015; Price et al., 2010).

Initiatives to develop a set of clear indicators for BR evaluation do exist at the national level, e.g. within the German MAB network (Scherfose, 2013). In Germany, a bold initiative was carried out to increase efficiency of large-scale PAs management by harmonizing the criteria systems for all types of PAs. This also allowed for comparison and national appraisal of deficits and successes (Scherfose, 2013). However, such an approach is needed at the international level. To be able to achieve this, there is a need for UNESCO-MAB Secretariat to provide a standard set of indicators that can be used adaptively for the evaluation of BRs (Matar, 2015).

Biosphere reserves evaluation: The Periodic Review process

Periodic review process: definition and aim

In response to the identified need for the evaluation of BR concept implementation, the PR process was introduced in 1995 as part of Article 9 of the *Statutory Framework* adopted by the MAB International Coordinating Council (ICC) (also referred to as MAB Council) and general Conference of UNESCO:

…the status of each BR should be subject to a PR every ten years, based on a report prepared by the concerned authority, on the basis of the criteria of Article 4, and forwarded to the secretariat by the State concerned. The report will be considered by the Advisory Committee for BRs for recommendation to International Co-ordinating Council. (UNESCO, 1996, p. 18).

Price (2002, p. 15) stated that the ultimate aim of the PR process is that "BRs achieve the recognition as the sites of excellence that they should be […] by ensuring within a reasonable period, that all members of the WNBR do fulfil the three complementary and mutually reinforcing functions of BRs". On the other hand, the UNESCO-MAB Secretariat defines the PR process and its objective as:

…a time to take stock of progress made by the BR, especially as concerns the updating of knowledge, skills and expertise in resource and ecosystem management. It also provides an opportunity to discuss the updating of the zonation system and assess its relevance, question the objectives and means of management policies and examine the issues and problems tied to implementation. It is also a time to discuss weak points. Its objective is to improve the quality of the BRs and their functioning as sites for testing and demonstrating approaches to sustainable development. (UNESCO, 2016c).

The requirement for PR reporting was re-iterated as Target 9 of the MAP (UNESCO, 2008, p. 15): "all BRs undertake PR and related actions to update zonation, management and other changes to meet Seville and MAP requirements and recommendations", under the responsibility of the MAB National Committees as focal points.

Periodic review procedures

As defined in Article 9 of the *Statutory Framework*, as of 1995, the PR review is requested from all BRs ten years after their designation year. The detailed procedure entails the following steps (Price, 2002; Price et al., 2010; Reed & Egunyu, 2013):

Step 1: The MAB Secretariat sends the request for a PR report to the State (or National UNESCO-MAB Authority) of the BR to be reviewed;

Step 2: The State sends the report to the MAB Secretariat who transmits it to the International Advisory Committee for Biosphere Reserves (IACBR) who reviews it and makes recommendations to the ICC;

Step 3: The ICC reviews the report, assesses it against the criteria of Article 4 (describes the criteria that define a BR) (UNESCO, 1996, p. 16-17) of the *Statutory Framework*. If the PR is judged satisfactory, the positive result is communicated to the UNESCO-MAB Secretariat who then transmits the decision to the National Authority (steps 4-7 no longer apply). If the report is not satisfactory, the ICC sends recommendations for better compliance to the MAB Secretariat;

Step 4: The MAB Secretariat transmits the recommendations for improved compliance to the concerned National Authority;

Step 5: After a 'reasonable period', the National Authority is expected to send back to the MAB

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Secretariat an updated report with evidence of corrective actions based on recommendations;

Step 6: The IACBR reviews the updated PR report and makes a recommendation to the ICC;

Step 7: The ICC makes a final decision, which could be summarized as either 'satisfactory' or 'unsatisfactory'.

If the PR report is unsatisfactory due to its quality or lack of local capacity to complete the PR, the IACBR can recommend assistance from the relevant UNESCO Regional Office to guide the BR management team in preparing the PR; this recommendation is reviewed by the ICC before it is sent to the concerned authority by the Secretariat (G. Ramadan-Jaradi, personnal communication, November 8, 2013). If the final PR evaluation outcome remains unsatisfactory after potential assistance from UNESCO, the ICC can notify the UNESCO Director General that the reviewed BR will be withdrawn from the WNBR. Alternatively, the concerned State can voluntarily announce to the Secretariat the withdrawal of the BR from the WNBR at any stage of the evaluation if it finds it not possible to fulfil the criteria or make the necessary/recommended changes to improve compliance (Price, 2002; Price et al., 2010).

Periodic review report: content and requirements

The PR report is used by UNESCO-MAB Secretariat for (1) review by the IACBR and ICC for appraisal of the BR, and (2) updating the BR's information on the official website (also called UNESCO-MABnet) and the WNBR directory. On the other hand, it is unclear whether local BR authorities are using PR reports for any management purposes besides reporting to UNESCO-MAB Secretariat. However, the implementation challenges including non-response and delays, in addition to the absence of published studies on the subject, suggest that local BR authorities complete the PR report for no other purpose than compliance with UNESCO-MAB requirements.

The first PR form (1996) designed by the UNESCO-MAB Secretariat was utilized by most BRs who conducted PR reviews (till 2015). In January 2013, based on the MAP Target 1.4: "Update the […] PR forms for BRs by 2010" (UNESCO, 2008, p. 11), a new version of the PR was published by the UNESCO-MAB Secretariat. The new PR form is readily available online for download by relevant parties in three languages: *English*, *French*, and *Spanish* (UNESCO, 2016c). The form's updates reflect the evolution of the BR concept and overall MAB strategy changes (UNESCO, 2015). Compared to the old form's template (23 pp), the new one is substantially longer (43 pp) and adapted to the conceptual changes made in the BR definition since 1996, especially after the MAP in 2008. The range of subjects is more comprehensive, and questions under each category are much more specific, requesting detailed information. Table No. 1 presents a comparison of the main structure for the body of text of the two versions of the PR form, illustrating the main changes made.

Comparison of structure for the old and new versions of the Periodic Review (PR) Form.

Structure	Old version titles (1996)	New version titles (2013)
Chapter 1	Name	Biosphere reserve
Chapter 2	Country	Significant changes in the biosphere reserve during the past ten years
Chapter 3	Physical characteristics	Ecosystem services
Chapter 4	Zonation	The conservation function
Chapter 5	Human activities	The development function
Chapter 6	Research and monitoring programmes	The logistic function
Chapter 7	Education, training and public awareness programmes	Governance, biosphere reserve management and coordination
Chapter 8	Institutional arrangements	Criteria[1] and progress made
Chapter 9	Conclusion: Criteria[1] and progress made	*N.A.*[2]

[1] Refers to Criteria of Article 4 of the *Statutory Framework* (UNESCO, 1996)
[2] *NA – Not Applicable*

Table No. 1

As Table No. 1 shows, important changes include: (i) reporting on amendments made and actions taken based on the ICC recommendations in the case of second reports (new version, Chapter 2); (ii) emphasizing the BR functions fulfilment as well as governance, management and coordination, by creating a Chapter for each subject (new version Chapters 4-7); and (iii) introducing the "ecosystem services" dimension of BRs (new version, Chapter 3). In addition, although not reflected in Chapter titles (Table No. 1), the 2013 PR Form introduces an emphasis on the role of BRs in "climate change" and social aspects such as "gender mainstreaming", which clearly reflect the future strategic directions of the MAB programme (UNESCO, 2015). Based on document analysis, the questions in the PR forms are mostly descriptive in nature, inquiring about the

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"what", "how" and "who", of each of the above questions, in the perspective of assessing the degree to which the BR concept is being well implemented. Chapter 9 in the old form - equivalent to Chapter 8 in the new one, (Table No. 1) specifically requests from the reporting BR authority to justify how each of the *Statutory Framework*'s Article 4 criteria are being fulfilled. Both forms require an Appendix, the provision of supportive documentation including maps, species lists, legal documents and land use plans etc., as well as updated contact information and media that would be used for the online directory of the WNBR (i.e. on UNESCO-MABnet).

Periodic review implementation

Periodic review response. According to the MAB Secretariat, the number of PR reports received and examined by the ICC has reached a total of 370 (UNESCO, 2016c). Reports are completed by various parties including site managers, national MAB Committees, and/or consultants. Some countries reported taking additional actions in preparation of the review process and based on its requirements. These included national level participatory processes leading to a review of a wider scope of issues related to all reserves in the country, and and extension of the BR zones in order to better apply the BR conceptual requirements (Price, 2002).

As of 2016, the review of submitted reports has resulted in the withdrawal of 18 BRs from the network, all of which were designated very early in the programme between 1976 and 1986 (UNESCO, 2016c, 2016d). With the exception of two BRs in Australia, all withdrawals are from Europe, and are done voluntarily after the PR process reveals gap(s) that are not possible to fulfil (Price et al., 2010; UNESCO, 2016d). For example, in the UK, the PR review process led to a national evaluation of all sites, after which the government decided to withdraw four BRs that didn't fulfil the criteria (Price et al., 2010). The UK now has the highest number (eight) of withdrawals from the WNBR (UNESCO, 2016d). In this instance, factors influencing the decision included: absence of human settlements within the overall BR area, difficulty to redefine and/or expand certain zones for better compliance with the functional zonation scheme, need for organizational arrangements for involvement and participation of stakeholders, and need for more integrated BR management plans and policies and implementing agency (Price et al., 2010). Some or all of these factors could not be structurally accomplished and/or would not be cost-effective to operate especially given the resources needed and the (sometimes) limited benefit the BR designation would bring to sites that are already well managed for conservation purposes at the national level (Price, 2002; Price et al., 2010; Stoll-Kleemann et al., 2010). On a more positive side, 352 BRs remained within the WNBR after submission of their PR reports. Some of these BRs had to make effective zonation changes or comply with other recommendations from the ICC before approval of their PR reports.

Periodic review implementation benefits. Compared to the pre-Seville period, the introduction of the PR process by the MAB Secretariat proved beneficial to the compliance and alignment of the BR implementation with the BR concept. At the site level, improvements were made through improved zonation and integration of functions, and increased dialogue between stakeholders and UNESCO-MAB institutions (UNESCO, 2014a). Overall, the PR process has been successful in the collection of updated information concerning the WNBR and consolidating the BR concept. The PR increased the value and credibility of the MAB programme throughout the network by enforcing adherence to the requirements, and implementing withdrawals when necessary. However, the PR monitoring system has encountered many challenges, some of which were addressed by the MAB Secretariat, while others prevail (Price et al., 2010).

Implementation challenges faced by the UNESCO-MAB Secretariat. A summary of PR submission dates for BRs globally shows that many reports are submitted with several years of delay (UNESCO, 2014b). For example, a recent study on the ArabMAB Network showed that 43 percent of outstanding PR reports were not submitted due to delays or non-response (Matar, 2015). In parallel, the acceptance of these reports by UNESCO-MAB Secretariat despite the delays reflects a large flexibility regarding the ten-year submission due date. In 2009, the ICC reported that 220 PRs had already been submitted to the MAB Secretariat, but one fifth of the Member States (21 countries) had not yet submitted any PR reports despite the fact that some of their BRs were designated before 1996 (UNESCO, 2009, p. 1).

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Again in 2010, submissions were 130 reports short of 359 for BRs designated before 2000, indicating a continuous gap in response levels to the PR requirement (Price et al., 2010). The problem of non-response also applied to BRs that received recommendations by the MAB Secretariat for corrective measures, based on a first submission (Price et al., 2010).

To address the issue of delay and non-response, the MAB Secretariat introduced the Exit Strategy in 2013 (UNESCO, 2014a). Briefly, the strategy consists of sending 'warning letters' to non-respondents with compliance deadlines. If the concerned State doesn't send any feedback, the MAB Bureau (elected representatives of the ICC) reserves the right to recommend to the ICC the withdrawal of the BRs from the WNBR. By 2014 the Exit Strategy 'threatened' around 266 BRs in 76 countries (UNESCO, 2014c), reflecting the high level of non-compliance with PR reporting and/or recommendations so far. The first stage of implementation of the Exit Strategy increased response levels with many new PRs received in direct response to 'warning letters' (UNESCO, 2014a). In addition, UNESCO-MAB has set a final deadline for complying with Article 4 criteria either through PRs or responses to recommendations i.e. follow-up reports (UNESCO, 2014a).

Implementation challenges at the national and local levels. Various parties, including national MAB committees, consultants and BR managers, with different financial means and level of expertise, complete PR reports. The main identified challenges for effective PR reporting and compliance relate to technical and financial capacity. First, the cost of the PR evaluation procedure and expert fees can be prohibitively high in some countries. Price and colleagues (2010) conducted a first assessment of costs to prepare one PR report, showing a wide range that starts at 2 200 USD in Canada where the evaluation is conducted by volunteer experts but can reach up to 43 000 USD in France (Price et al., 2010, p. 552). However, a broader research on this subject is needed for a more accurate world estimate since this evaluation was limited to eight countries and hence does not represent the WNBR geographical diversity (Price et al., 2010). Second, the lack of human or financial resources for operating required changes at the site level - for fulfilment of criteria and recommendations - was also reported as a limiting factor to compliance. In some cases, these costs weighted against 'perceived benefits' led to the authorities' decision to withdraw from the WNBR. Examples include the Australian Southwest BR and five other sites in the UK, where the BR designation was not perceived to be adding much value to those sites with a conservation focus (Price et al., 2010). In response to these challenges, the UNESCO-MAB Secretariat has expressed a commitment to offer technical support through UNESCO's regional offices.

Periodic review limitations, and progress made on existing recommendations for improvement

Limitations of the periodic review tool and process. Until 2010, the effectiveness of the PR process as a tool for 'quality-control' was criticized due to weak enforcement of withdrawing non-compliant BRs from the WNBR (Price et al., 2010). However, the recent (2013) introduction and implementation of the Exit Strategy suggests that UNESCO-MAB Secretariat is addressing this issue through stricter enforcement of reporting (UNESCO, 2014d).

On the other hand, the PR review process presents some inherent limitations similar to PAME evaluation tools. Indeed, the PR process is a self-assessment subject to non- transparency and bias from several sources throughout the process, especially from the interviewee, and evaluator (i.e. how the evaluator understands the PR influences the result) (Anthony, 2014; Burnard, 1991; Cook & Hockings, 2011; Matar, 2015; Papp, 2011; Stoll-Kleemann, 2010; WWF, 2007). The MAB Secretariat attempts to mitigate this limitation by requesting supportive documents to the PR claims as part of the PR Report (UNESCO, 2013). Moreover, the IACBR encourages the PR evaluation to be a cooperative process involving stakeholders representing the array of involved parties in the management of the BR (Price et al., 2010). If implemented, collaborative reporting processes would reduce the interviewee and evaluator bias (Cook & Hockings, 2011), however many countries still lack the resources and infrastructure necessary to ensure stakeholder involvement (Price et al., 2010). In addition, on-the-ground validation mechanisms by the UNESCO-MAB Secretariat are still missing for crosschecking qualitative information provided in the PR.

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Finally, the ten-year PR reporting timeline has been criticized as "too long to effectively monitor changes occurring in BRs or actions taken to respond to recommendations" (Price et al., 2010, p. 555).

Previous recommendations for improvement and progress made. Research and documentation on effectiveness of the PR process and implementation locally and regionally is still very limited. The UK and Canadian practices are the only national experiences published in the peer-reviewed literature to date. These, in addition to a review of international implementation - incorporating internal knowledge from UNESCO-MAB Secretariat (Price et al., 2010), provided the basis for the development of recommendations for improving the PR process. Main recommendations included:

- UNESCO-MAB Secretariat to update the PR Form (design a new form) and correspond with National MAB Committees to undertake periodic reviews;
- Establish information-sharing platforms and mechanisms to be used for sharing information about the purpose and benefits of PRs, PR reports and best practices (Price, 2002);
- Reduce the reporting timescale from ten to five years, for more effective tracking of progress over time (Price et al., 2010);
- Emphasize shifting the BR evaluation discourse from a "stick and carrot" procedure where the PR is perceived as an imposed procedure to overcome by BR stakeholders, to a collective learning process engaging multiple stakeholders and used for adaptive management (Bouamrane, 2007).

The objectives of these recommendations are to enhance the understanding of the PR process and its benefits, emphasize its 'learning' aspect, and ultimately improve management effectiveness of BRs.

Progress made based on these recommendations is variable. The PR was updated in 2013 but it is still too soon to assess the impact of this change on effectiveness of the process. As for information sharing, the UNESCO-MAB Secretariat has shared a limited number of "model PR reports" on its official website, to provide an example for BRs to follow (UNESCO, 2016c). However, a larger scale open platform for sharing PR resources and best practices is still lacking, and the reports remain internally shared only. Therefore limited opportunity exists to exchange knowledge and technical capacity within the WNBR, or even at the level of regional networks, for the improved effectiveness of the PR process. Moreover, downscaling the timeframe for PR evaluation to five years was abandoned after being seriously discussed in the IACBR, partly because the number of reviewers is limited, while the number of submitted reports is expected to double (G. Ramadan-Jaradi, personnal communication, November 8, 2013). Moreover, according to Price and colleagues (2010), a five-year period was considered too short to make the type of changes that ICC would recommend after one PR process, such as zonation changes. Finally, the use of evaluation as part of a systematic and adaptive management cycle is a widely established and recommended approach for the effective management of PAs and BRs (Gormley et al., 2015; Kingsford et al., 2011; Schultz et al., 2011). However, the design of the PR Form (increased in length in 2013), prohibitive cost of the process, and lack of local capacity and resources, decrease the possibility of adopting this recommendation. In addition, adaptive management intrinsically includes evaluation as a continuous iterative process, which needs to be done systematically and frequently (Folke et al., 2005; Holling, 1978; Williams, 2011). In that perspective, a ten-year period between evaluations is too lengthy and in contradiction with the nature of adaptive management.

Transferring lessons from the Protected Areas Management Effectiveness (PAME) evaluation to the Periodic Review (PR) evaluation

Based on relevant literature and on the methodologies used for PAME and BR evaluation, we summarize here relevant characteristics of PAME evaluation tools in comparison to UNESCO's PR tool (Table No. 2). The list of characteristics is by no means comprehensive, especially in characterizing the PAME evaluation tools since they are very diverse. A case-by-case evaluation would be needed otherwise to compare each PAME evaluation tool to the PR Form. However this comparison provides a general picture that facilitates the identification of limitations inherent to the PR tool, and the evaluation of its appropriateness for adaptive management approaches to BRs fostered by the UNESCO-MAB Secretariat

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and experts (Bouamrane, 2007; Reed & Egunyu, 2013).

Comparison of the PAME and PR evaluation tools characteristics.

PAME evaluation tools	UNESCO's Periodic Review tool
Based on the same (WCPA) Framework, but flexible and customizable to the case of each PA.	Standard Form, not customizable to the case of each BR.
Includes quantitative and qualitative evaluation.	Only qualitative and largely descriptive.
Can be used for a frequent and iterative evaluation process embedded in the PA management cycle i.e. for adaptive management.	Required only once every ten years, and is not practical nor designed to be systematically used for iterative evaluation i.e. adaptive management.
Utilized for global reporting and compliance with the CBD requirements.	Remains a largely "top-down" and internal requirement by UNESCO-MAB Secretariat.
Generally useful to PA managers, and practical to integrate in internal management procedures for adaptive management.	Generally perceived as a "cumbersome" and administrative procedure by BR managers.
Evaluates outputs and outcomes.	Evaluates *whether plans exist to evaluate outputs and outcomes*, but does not evaluate outputs and outcomes.
Addresses the question *how far are you from optimizing the management of your PA?* i.e. 'present to future oriented'.	Addresses the question *what actions have you taken so far to implement the BR concept?* i.e. 'past to present oriented'.
Presents the limitations of subjectivity and evaluator bias due to self-evaluation.	Presents the limitations of subjectivity and evaluator bias due to self-evaluation.
Requires triangulation with supportive hard evidence to validate self-evaluation.	Requires triangulation with supportive hard evidence to validate self-evaluation.

Table No. 2

Perhaps the most important difference between the suite of PAME evaluation tools and the PR tool is that the latter is not designed to assess effectiveness ofall aspects of management, but rather focuses on assessing whether the BR conceptual characteristics - including the three zones (core area, buffer zone, transition zone), and related functions (conservation, sustainable development and logistic support) have adequate implementation plans and programmes of work, and that the basic governance arrangements required by the programme are fulfilled (e.g. an appropriate management plan). Though this is a very important part of the evaluation, it is insufficient for providing a comprehensive evaluation of the performance of BRs in reaching their functions.

Drawing from the lessons learned concerning methodologies for evaluation in the PAME discourse, many criteria identified for effective evaluation are still partially or fully unfulfilled with the PR process and tool. According to the six criteria of effective evaluation (Leverington et al., 2010a; Pomeroy et al., 2014), we find that:

(1) its level of usefulness to local managers and stakeholders is still questionable, and more research on local BRs at a larger geographical scale (beyond Europe and North America) and/or regional networks is needed to further address this question;

(2) its practicality in use and cost varies but so far PR reporting is resource-intensive and can therefore be perceived as a burdensome requirement to be fulfilled by BR staff only for the benefit of retaining the international UNESCO-MAB designation;

(3) though it has been reported that the PR process is increasingly involving stakeholder-participation, many BRs lack the infrastructure for participatory processes and the resources to develop such infrastructure; in addition broader scale studies on PR processes locally are needed to assess feasibility and adoption of stakeholder participation in developing as well as developed countries;

(4) flexibility for use in different sites and conditions is not a characteristic 'by-design' of the PR form, neither is its use for a comprehensive evaluation of BR management performance (functional outputs and outcomes);

(5) the tool is not designed to effectively integrate into a frequent and iterative systematic evaluation process that meaningfully contributes to an adaptive management cycle; and

(6) holistic indicators balancing human and natural perspectives are largely missing as the PR formonly inquires whether 'indicators exist' without providing the relevant social ecological and economic indicators themselves.

What's next for UNESCO biosphere reserves evaluation?

So far there is no one international account and database of BRs' performance in achieving their conservation, sustainable development, and logistic functions that would be 'equivalent' to global reviews of performance for other models of conservation sites, such as the Global Study (Leverington et al., 2010a, 2010b) and GD-PAME for PAs. Though efforts have been made to update the PR tool and increase compliance, there are still serious pitfalls in the evaluation system of BRs management and effectiveness. Notably, there is a "lack of indicators and mechanisms to review effectiveness in BRs" (Lotze-Campen et al., 2008, p. 113) that has

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continued since 1995. Therefore, the UNESCO-MAB is one international programme that requires more focused attention to improve the rigor of its management effectiveness evaluation, and the transparency of its performance with the aim of enhancing the effectiveness of global concerted efforts toward reaching the international sustainability goals (i.e. Sustainable Development Goals).

The increasing complexity of reporting for sites with multiple overlapping designations, combined with often-limited resources available for this purpose, creates the responsibility and need to identify knowledge-sharing opportunities and synergies between programmes at the level of management and reporting (Schaaf & Clamote Rodrigues, 2016). Given the close conceptual and physical connections between PAs and BRs, and the continuing relevance of quantifying performance for PAs and BRs (Gray et al., 2016), we suggest that there is an opportunity to develop an evaluation tool (with set indicators) for management effectiveness evaluation of UNESCO BRs based on the accumulated knowledge and experience of PAME evaluation tools and their implementation.

This review identifies several gaps that need to be addressed for a more effective contribution of the UNESCO BRs to the global conservation and sustainability goals. Management effectiveness includes aspects of design, adequacy and appropriateness of management systems and processes, and delivery of objectives (Hockings et al., 2006). We argue that while the PR helps ensure the first two aspects of BR effectiveness are met, the third aspect "delivery of BR objectives" is still lacking proper evaluation. Hence, evaluation needs to more rigorously measure outputs and outcomes. For BRs, this is not limited to the conservation value but should appropriately evaluate sustainable development and logistic support outcomes as well. Therefore there is a need to develop performance-based standard indicators adapted to the BR conceptually and contextually, which will allow quantification of effectiveness. In order to develop criteria and indicators for evaluation of the sustainable development and logistic functions, there should be clear standard guidelines on the management and expectation outcomes of all three zones. Using a totally different approach, similar recommendations have been made to UNESCO based on a review of BR effectiveness in the Asia-Pacific region (Meijaard et al., 2010); a fact that consolidates our conclusions.

Moreover, PR evaluation is effective at reviewing compliance with the zoning scheme as well as making sure that plans to implement the three functions exist and are operational. However, it should not function as a stand-alone MEE tool, as it fails to adequately assess performance. BR MEE is a different type of evaluation that must be results- based, systematic and integrated into the BR management cycle. The PAME evaluation lessons provide us with transferrable criteria of effective evaluation, which can be leveraged for the creation of an innovative standardized tool for the MEE of BRs. The new tool would complement the PR by serving a different purpose. While the PR evaluates "effectiveness of concept implementation", the BR MEE tool would evaluate "effectiveness of management of the BR", and would be more practically integrated into the BR management cycle allowing for evaluation on a shorter timescale. Based on this review we argue that the new BR MEE tool needs to incorporate characteristics of improved PAME evaluation tools in order to compensate for the persisting gaps of the PR reporting system.

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Acoustic Ecology in UNESCO Biosphere Reserves

Leah Barclay Queensland Conservatorium Research Centre, Griffith University, Australia
Toby Gifford Queensland Conservatorium Research Centre, Griffith University, Australia

ABSTRACT: Acoustic ecology is a dynamic interdisciplinary field that studies the social, cultural, and ecological aspects of our environment through sound. In the context of UNESCO biosphere reserves that seek to reconcile the conservation of cultural and biological diversity, acoustic ecology offers valuable tools to understand environmental and cultural changes from a diversity of perspectives. Biosphere Soundscapes is a large-scale interdisciplinary research project conceived in 2011 that studies and records the changing soundscapes of UNESCO biosphere reserves. The project is underpinned by the creative possibilities of acoustic ecology and rapidly emerging fields of biology concerned with the study of environmental patterns and changes through sound. Biosphere Soundscapes sits at the intersection of art and science, with the recordings providing valuable scientific data for biodiversity analysis and rich source material for education programs, community engagement and creative works that bring awareness to these environments. This project is designed to inspire communities across the world to listen to the environment and explore the value of sound as a measure for social, cultural and environmental health in UNESCO biosphere reserves. Biosphere Soundscapes is delivered through immersive residencies with artists and scientists, research laboratories, intensive masterclasses, virtual education programs and a diversity of creative projects spanning four continents. This article outlines the development of the project and introduces the framework of Biosphere Soundscapes through recent projects in Mexico and Australia designed to provide insight into the possibilities of acoustic ecology and practical pathways for biosphere reserves to engage with the project. Biosphere Soundscapes is designed as a platform for local and global communities to connect and collaborate in exploring the creative and scientific possibilities of acoustic ecology in UNESCO biosphere reserves.

Keywords: acoustic ecology, ecoacoustics, bioacoustics, soundscape, remote sensing

UNESCO Biosphere Reserves & Acoustic Ecology

Biosphere reserves are sites recognized under UNESCO's Man and the Biosphere Program (MAB) to promote innovative approaches to sustainable development. There are currently 669 biosphere reserves in 120 countries comprising terrestrial, marine and coastal ecosystems. As interdisciplinary learning laboratories for sustainability, biosphere reserves present an incredible opportunity to connect and engage communities in innovative approaches to the conservation of biological and cultural diversity. Local communities of biosphere reserves are encouraged to test and demonstrate innovative approaches to ecosystem monitoring and sustainable development and share their learnings with other biosphere reserves. The World Network of UNESCO Biosphere Reserves presents a valuable platform for community capacity building and knowledge sharing in response to the ramifications of climate change. Biosphere reserves can act as a model in inspiring global communities to develop innovative, responsive and adaptable approaches to climate action.

The underpinning causes of climate change remain to be engrained in unsustainable actions that call for dramatic social and cultural changes. This requires a reframing of climate change to embrace interdisciplinary approaches and inspire communities to take urgent action. Hoffman (2012) believes greater inclusion of the social sciences in climate change mitigation and adaptation could assist in galvanising public engagement. Boulton (2016) believes the current framing of climate change does not account for cultural and ontological dimensions and we need to draws on interdisciplinary research to engage our sensory abilities. The network of

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UNESCO biosphere reserves offers a critical platform for public awareness, strengthening adaptability and community engagement in climate change mitigation locally, and globally. In order to have this impact, communities of biosphere reserves must be aware of their local and global value, engaged in participatory projects and inspired and empowered to take action.

In our visually dominant society, listening has a profound ability to make us feel present and deeply connected to our surrounding environment. Our auditory perception reveals more about the state of our environment than any other sense and has the capacity to process highly complex information. Listening to the soundscapes that surround us at any given moment provides us with a rapid understanding of the social, cultural and ecological contexts of our environment. From a dawn chorus deep in the Central Amazon Biosphere Reserve of Brazil to traditional songs in the Tonlé Sap Biosphere Reserve of Cambodia, sound offers an inherently interdisciplinary medium to understand place. The temporal complexities of our sonic environment offer profound ways to understand subtle changes in cultural and biological diversity in UNESCO biosphere reserves. This notion is core to the field of acoustic ecology, founded by R. Murray Schafer in the late 1960s in Canada. His premise was that we should attempt to hear the acoustic environment as music and we should take responsibility for its composition (Schafer 1977).

Acoustic ecology studies the social, cultural, and ecological contexts of our environment through sound. It is an interdisciplinary field crossing humanities and sciences, with constantly evolving possibilities for understanding ecological changes through sound. R. Murray Schafer was actively involved in education and advocated for integrating listening skills and 'sonological competence' into the school curriculum as a means to inspire younger generations to be more connected to their surrounding environment (Wrightson 1999). Schafer's book The Tuning of the World, published in 1977, remains one of the most pivotal resources on acoustic ecology and understanding our sonic environment. The World Soundscape Project (WSP) was the first major acoustic ecology project in the 1960s that evolved from Schafer's course in noise pollution at Simon Fraser University. WSP was initially formed as a research group producing an array of projects, including the Handbook for Acoustic Ecology, edited by Schafer's colleague Barry Truax. This publication has a specific focus on terminology but showcases the truly interdisciplinary foundations of the field in crossing disciplines including acoustics, music, linguistics and sciences (Truax 1978).

While the foundations of acoustic ecology centred on noise pollution, the field has evolved into an accessible and dynamic interdiscipline concerned with the entire spectrum of our sonic environment. It continues to expand and broaden across sciences and humanities and insects with numerous other disciplines. Acoustic ecology informs critical discourse on environmental changes in fields including landscape ecology, geography and emerging fields of biology concerned with environmental patterns and changes through sound.

Bioacoustics and Ecoacoustics

In parallel with the development of acoustic ecology, the scientific field of bioacoustics has burgeoned in the last few decades. Bioacoustics is the study of sounds produced by animals (Krause 2002) with a historical focus on animal communication. More recently the field has additionally studied the use of animal sounds for wildlife population monitoring. Particular impetus for developing acoustic monitoring techniques has been provided by advances in computing technology which afford automated analysis of audio recordings, and recognition of "acoustic signatures" of particular species (Duan et al. 2011), or even particular individuals (Aubin et al. 2002). Automated acoustic monitoring can substantially mitigate the effort and expense associated with other monitoring techniques (such as visual observation, or expert listening by a researcher in the field) and can also be less intrusive, for example compared with trapping in wildlife cages.

Influenced by thinking amongst the acoustic ecology community, bioacoustics researchers have increasingly also considered the interaction between animal sounds and the acoustic environment, both natural and anthropogenic, with the realisation that anthropogenic noise should sometimes be considered as an aspect of environmental degradation, with potentially serious consequences for animal behaviours mediated through sound. Furthermore,

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beyond questions of noise pollution, soundscapes encode abundant information about the ecology of the environments producing them. The notion of holistic analysis of entire soundscapes, originating primarily from the World Soundscape Project at Simon Fraser University (Schafer 1977), has filtered into bioacoustics with the development of the subfields soundscape ecology (see Truax & Barrett 2011) – mediated via interdisciplinary researchers in landscape ecology and wildlife recording; and ecoacoustics (Sueur & Farina 2015) via remote sensing and quantitative ecology.

Ecoacoustics considers environmental soundscapes in their entirety, and treats sound as an instrument for probing ecological variables (Sueur & Farina 2015). A defacto assumption of ecoacoustics is that some form of acoustic complexity can be used as a proxy for biodiversity and ecosystem health. Correspondingly the field has developed a number of acoustic indices, i.e. statistical aggregation techniques distilling the soundscape to a single number, or series of numbers over time, that attempt to capture the notion of acoustic complexity. Acoustic indices provide readily visualisable indicators of ecosystem change. It should be noted however that conflation of acoustic complexity with biodiversity and/or ecosystem health is argued by us to be an oversimplification (Linke et al. 2016).

Listening and Perception

Bioacoustics, ecoacoustics and soundscape ecology all share the notion of environmental sound as data. Acoustic ecology additionally considers aesthetic properties of sound. The use of environmental field recordings as raw materials for soundscape composition is a key strategy in acoustic ecology for communicating complex acoustic features of the environment and for inspiring community engagement (Barclay 2013). Furthermore, an article of faith for acoustic ecology (and other arts-science interdisciplines) is that aesthetic inquiry can provide novel and useful perspectives for scientific studies of the phenomena under investigation (Monacchi 2013; Burtner 2011; Malina et al. 2013; Harris 2016).

A common dictum in practical data analysis is to always visually examine data prior to performing statistical calculations. Data visualisation is a field unto itself, seeking ways of representing structural aspects of data in visual form. There also exists the less well known field of auditory display, which seeks to represent data in audio format. In the cases of bio- and ecoacoustics, the data is already in audio format, and yet listening to field recordings does not rank as a core method in these disciplines. Partly this is pragmatic; ecoacoustics in particular tends to generate very large data-sets; a tendency which will likely increase as long-term large-scale acoustic monitoring programs become more feasible (for example Kasten et al. 2012). Indeed, ecoacoustics is recommended by some research groups as a means of visualising audio data (Dema et al. 2016). Partly also this eschewing of listening reflects an epistemic stance, endemic in the sciences, that seeks to remove perception from observation.

A practical consequence of this epistemic divergence between acoustic ecology and ecoacoustics is starkly differing approaches to field recording, particularly in regard to sound quality. In ecoacoustics it is common to record in 'mono' – i.e. a single channel, using low sampling rates and omnidirectional microphones with flat frequency response. The reasons are eminently practical: data storage, power consumption, bandwidth requirements and processing time are all mitigated by lower sample rates and fewer channels. Omnidirectional microphones give the most comprehensive spatial coverage per channel, and flat frequency responses aim to maintain 'fidelity' (i.e. the accuracy of representation) of the recorded signal to the actual sound in the environment. The acoustic indices to be calculated are monophonic, and so stereo recording for example would be redundant.

For acoustic ecologists, on the other hand, sound quality is paramount. Quality here refers not to a hierarchical judgement of high vs. low, but rather in the extended sense of qualia - the "distinctive subjective feelings that accompany sensory experiences" (Huron 2006:1676). Field recordings are commonly made in stereo, or even higher channel counts, at the highest possible sampling rate, with directional microphones, selected for their sonic character and low noise floor more than the flatness of their frequency response. A key driver of these choices is the desire to reproduce perceptual qualities and recreate experiences of being present in these environments as a means for ecological engagement (Monacchi 2016; Barclay 2013). To this end specialised recording techniques such as binaural

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(Rumsey 2012) and ambisonic (Gerzon 1992) are frequently employed.

A benefit of recordings that can recreate perceptual qualia, particular spatial acoustic 'image', is the ability of the human ear to perform complex auditory scene analysis tasks such as localisation and stream segregation (Bregman 1990). These tasks are highly evolved perceptual mechanisms for decomposing a soundscape into components associated with inferred physical sources, and the ease with which we perform them belies an extraordinary complexity that eludes computational implementation as yet, despite Computational Auditory Scene Analysis being an active field of research for several decades now (Wang & Brown 2006).

Interdisciplinary Possibilities in UNESCO Biosphere Reserves

While the term ecoacoustics is often interchangeable with acoustic ecology, it is clearly a distinctive field with a scientific focus that studies sound along a broad range of spatial and temporal scales to understand environmental changes (Sueur and Farina 2015). Acoustic ecology incorporates these emerging scientific disciplines, but offers a broader scope to explore the social and cultural contexts of our environment through sound and active listening. In the context of UNESCO biosphere reserves, the opportunities for these emerging disciplines is increased with new advances in reliable, accessible and affordable audio recorders that can be distributed throughout the community. These audio recordings provide critical data for biodiversity analysis and the process of collecting these recordings facilitates opportunities for community engagement and citizen science. Disseminating the resulting recordings on accessible virtual platforms could become critical to understanding the rapid ecological changes taking place across the globe.

In 2016, UNESCO adopted the MAB Lima Action Plan (2016-2025) during the 4th World Congress of UNESCO Biosphere Reserves. This document provides guidance and direction for the World Network of Biosphere Reserves and highlights the importance of embracing interdisciplinary perspectives in climate change mitigation and adaptation. The Lima Action Plan aims to harness lessons learned through sustainability science and disseminate the results globally through open, transparent and accessible platforms. The document acknowledges the critical importance of indigenous knowledge systems and calls on biosphere reserves to place greater effort into understanding cultural perspectives and embracing interdisciplinarity. This plan positions biosphere reserves as priority sites and observatories for ecosystem-based climate change action and living laboratories for the sustainable management of biodiversity through innovative research that embraces new technologies (UNESCO 2016).

The interdisciplinary potential of acoustic ecology and scientific possibilities of ecoacoustics are extremely synchronous with the Lima Action Plan. Particularly as ecoacoustics calls for greater collaborations with disciplines including electronics, remote sensing, big data and social sciences (Sueur and Farina 2015) and the scope of acoustic ecology embraces Indigenous knowledge systems and intercultural perspectives. Dr Leah Barclay was fortunate to deliver a presentation on acoustic ecology and the Biosphere Soundscapes project at the 4th World Congress of UNESCO Biosphere Reserves and contribute to the Lima Action Plan. Biosphere Soundscapes was identified as a valuable initiative that has the potential to investigate and reconcile biological and cultural diversity through soundscapes that represent all major ecosystems of our planet.

Biosphere Soundscapes Foundations: Noosa Biosphere Reserve, Australia

Biosphere Soundscapes is a large-scale research project drawing on the interdisciplinary possibilities of acoustic ecology. The project studies and records the soundscapes of UNESCO biosphere reserves and investigates environmental patterns and changes through sound. Biosphere Soundscapes sits at the intersection of art and science, with the recordings providing valuable scientific data for biodiversity analysis and incredible source material for education programs, community engagement and creative works that bring public awareness to these environments. The project seeks to explore and activate acoustic ecology from artistic, scientific and community perspectives. This project is designed to inspire communities across the world to listen to the environment and explore the value of sound as a measure for social, cultural and environmental health in UNESCO biosphere reserves.

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The interdisciplinary scope of acoustic ecology allows us to study the cultural diversity of biosphere reserves through traditional music, indigenous languages and oral history in addition to bio- and ecoacoustics approaches for species identification and analyzing environmental patterns and changes through sound. Biosphere Soundscapes is delivered through immersive residencies with artists and scientists, research laboratories, intensive masterclasses, virtual education programs and a diversity of creative projects spanning four continents. The project explores the possibilities of emerging mobile technologies in engaging the communities of biosphere reserves to listen to the environment. Empowering the local communities of biosphere reserves to document and map environmental change through non-invasive acoustic techniques is now realistic and possible. Sharing this with global communities and developing collaborations through virtual platforms has the capacity to strengthen the connectivity and potential of the World Network of UNESCO Biosphere Reserve.

Biosphere Soundscapes was conceived and developed by Dr. Leah Barclay in the Noosa Biosphere Reserve in Queensland, Australia. Noosa Biosphere Reserve was designated by UNESCO in 2007 and was the first biosphere reserve recognized in the state of Queensland. The biosphere reserve is home to over 44% of Australia's bird species, 1,365 species of plants, 711 species of native fauna and 60 distinct ecosystems. The biosphere reserve is recognized globally for its rich biodiversity and dynamic approaches to sustainability and community engagement. Barclay was the inaugural chair of the Noosa Biosphere Cultural Board and actively developed a series of interdisciplinary projects to demonstrate the importance of culture and creativity in designing governance models and community engagement strategies for the biosphere reserve. During the initial planning phase for the biosphere reserve, the Noosa Biosphere Cultural Board partnered with the Noosa Council to host Floating Land, a dynamic art and ecology event which has become a pillar of the local community.

Floating Land is biennial interdisciplinary festival hosted along the foreshore of Lake Cootharaba in the heart of the Noosa Biosphere Reserve. Conceived in 2001 as an outdoor sculpture exhibition, the festival has expanded into a vibrant interdisciplinary event that allows local and global communities to explore what it means to be a UNESCO biosphere reserve. While earlier iterations of the festival had a focus on sculpture and visual arts, the Noosa Biosphere Cultural Board instigated the emergence of interdisciplinary projects focused around science, technology, sound and acoustic ecology.

This interdisciplinarity was first introduced during the fifth iteration of Floating Land in 2009, a year after the Noosa Biosphere Reserve was designated. The provocative Floating Land 2009 theme, Climate Change and Rising Seas, allowed artists, scientists and community members to deeply consider methods of translating the complexities of the climate change debate into art and public engagement. Collaborators worked on the foreshore of Lake Cootharaba for a 10-day residency developing ideas, experiments and public artworks. Visitors to Floating Land could engage with artists by discussing ideas and contributing towards the development process onsite. The audience could participate in workshops, attend forums, experience performances and become immersed in the environment and stories of Boreen Point in the centre of the Noosa Biosphere Reserve.

Floating Land 2009 introduced an acoustic ecology workshop program developed and facilitated by Barclay to showcase the possibilities of understanding environmental patterns through sound in UNESCO biosphere reserves. Barclay was consequently commissioned to create Eco Sonus, a site-specific sound installation that captured the essence of the event through sound. This process initially involved community sound walks, field recording workshops and collaborative composition activities. It immediately become apparent to the community that sound was an immersive and embodied way to explore the cultural and ecological contexts of the event in a way that was synchronous with the vision of the Noosa Biosphere Reserve. The workshops with a more scientific focus included hydrophone (underwater) recording workshops in Lake Cootharaba that attempted to identify aquatic species and experiment with sound propagation. Participants created short water percussion rhythms and recorded how far they could travel underwater which merged into creative workshops composing soundscapes with the resulting recordings. The group created sound diaries and graphic scores detailing

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visual representations of the sonic environment beneath the surface of the water. The sounds of snapping shrimp underscored poetry written in response to the aquatic soundscapes and these compositions and recordings were made accessible to the local community in daily listening sessions.

During the Floating Land Sound Reflections workshop on June 22, 2009, participants were encouraged to record during the morning and then sculpt a sonic environment based on future scenarios through the afternoon. Boreen Point experienced a particularly large storm during the workshop that resulted in the sounds of water, thunder and rain being prominent in all of the recordings and resulting compositions. This provided an ephemeral and embodied way for participants to understand the temporality of weather and changing climates through sound, which was a transformational experience for many of the participants who have since continued to integrate acoustic ecology into their artistic practice.

Sound walks, listening activities and field recordings were conducted on a daily basis during Floating Land 2009. The resulting recordings and soundscapes from the 10-day residency were disseminated through the Eco Sonus sound installation, which involved site-specific performances that connected to a dynamic virtual platform accessible to a global audience online. This was designed as a pilot experiment to explore the value of virtual platforms as knowledge sharing tools and collaborative platforms for connecting with other biosphere reserves in Australia and beyond. The website was also developed as a tool to extend and expand the impact, engagement and awareness of the project.

In the initial days on site, it was fascinating to compare the interaction between members of the community with the photographers and the sound artists. Inquisitive individuals would follow the photographer, being very careful not to disturb the shot. In contrast, during the field-recording workshops, people were curious by the technology, and clearly not as conscious of disturbing this process. Visitors would interact with the field recordists, oblivious to the fact that their voice and footsteps were greatly impacting the recordings. Consequently, the project produced hours of recordings of community interactions, predominately revolving around explanations of field recording, conversations about the value of listening, and the discussion of local soundscapes. This became incredibly valuable material in itself, and very revealing about community perspectives on sound.

The initial on-site field recordings revolved around the foreshore of Lake Cootharaba. The collaborators worked with microphones close to the lake capturing subtle rhythms of the water lapping at the edge with hydrophones submerged deep in the water. Experimenting with these field recordings at low and high tides was a constructive method of capturing the changing signatures of the aquatic soundscape. Many of the compositions featured the voices of the local community; some were recorded in an interview format discussing the Floating Land theme, while others were recorded during informal moments capturing the highlights of the event. These evolved into sonic portraits of the artists and their projects, capturing the social and cultural layers on the event through sound. Barclay was particularly drawn to work with Eric Natuoivi, an installation and ceramic artist from Vanuatu. His Floating Land project, 'Ailan I Draun Long Solwarra' (Islands drowning in the Sea), was an immersive installation revolving around hand-carved totem poles and sculptured palm fronds that drew its inspiration from Vanuatu's traditional cultures.

On the first day, Eric waited on the shores of Lake Cootharaba in the wind and rain listening to the land to contemplate what he would create. While other artists' frantically gathered materials and identified sites, he was calm and reflective, actively listening to the environment and responding to his new surroundings. After the Welcome to Country by Gubbi Gubbi Elder Dr. Eve Fesl, Eric felt connected with the natural and spiritual environment of Lake Cootharaba and began work.

Eric welcomed the possibilities to document his project through sound and immediately spoke about the importance of listening to the environment. The compelling characteristic of working with Eric Natuoivi was his ability to weave stories through his creative process, connecting sounds and knowledge to each stage of developing his artwork. He spoke about cultural protocols as he placed rocks in a circle to represent a meeting place of the people of the land. He explained the meaning of totems as he carved

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posts with a small axe and spoke of the ancestral spirits, who are concerned about the rising seas and the fate of their people. One of his underlying messages was to inspire people to respect the environment through cultural understanding. 'We should cherish and safeguard the natural world to enrich the way we live', he said. His community was very aware of the effects of climate change and the dramatic ramifications of rising sea levels.

Eric's perspectives were synchronous with acoustic ecology, in actively listening to the environment and exploring ecological interconnections that weave with indigenous ways of knowing and understanding the world. This approach to embodied ecological connection and deeply understanding a place through sound, demonstrates that listening to the environment can reveal the interconnected nature of cultural and biological diversity. This notion of understanding place and environmental interconnection through sound is prevalent in Indigenous knowledge systems throughout the world, from Aboriginal songlines in central Australia to the Athirathram ritual of Nambudiri Brahmin families in in the backwaters of Kerala, South India which is derived from birdsong. Eric's perspectives on sound also resonate with Steven Feld's concept of acoustemology, exploring sound as a distinctive medium for knowing the world (Feld 1996). Acoustemology could be defined as acoustic epistemology and was initially inspired by Feld's research in the 1970s with the Kaluli people in South Central Papua New Guinea who have innate connections to their sonic environment.

Listening to the environment reveals that everything is connected in what Timothy Morton (2012) describes as the vast intertangling 'mesh' flowing through all dimensions of life. While Biosphere Soundscapes was not developed until two years later, it was this process of development during Barclay's 2009 Floating Land projects that solidified the value of sound and acoustic ecology as a way to explore the cultural and biological of UNESCO biosphere reserves. Listening to the Noosa Biosphere Reserve could reveal information about the health of the environment from scientific perspectives and pathways to gain deeper understandings of environmental interconnection from social and cultural perspectives. Actively listening to the biosphere reserve was an opportunity to be present and connected, and to inspire the community to understand the value of acoustic ecology.

Biosphere Soundscapes Framework

The interdisciplinary design of Biosphere Soundscapes was inspired by the Sonic Ecologies framework, an adaptable and responsive practice-led research methodology for embedding acoustic ecology projects in multi-platform community engagement and interdisciplinary partnerships to ascertain long-term impact and inspire a culture of listening (Barclay 2013). This framework was developed during Barclay's PhD and informed the multi-platform design of Biosphere Soundscapes.

The initial phase of the project had an explicit education focus to explore the artistic and scientific possibilities of accessible audio recording technologies and acoustic ecology in connecting and empowering local and global communities of UNESCO biosphere reserves. Biosphere Soundscapes was conceived in 2011 and officially launched on World Listening Day 2012 in Queensland, Australia, with a field recording expedition in the Noosa Biosphere Reserve, a symposium featuring international sound artists including Ros Bandt, Gerardo Dirié and Daniel Blinkhorn, and a pilot digital platform including a biosphere sound map. The launch was streamed live through the digital platform and also involved a guest video presentation with Joel Chadabe, the president of Ear to the Earth in New York City. The project was endorsed by UNESCO in 2013 and was the first international research initiative documenting the changing soundscapes of UNESCO biosphere reserves. The project was designed to be participatory and accessible for artists, scientists, in addition to the communities of local biosphere reserves. The recordings were contributing to a searchable database that would be useful to monitor ecological changes from biodiversity perspectives but also made available for artistic projects and aesthetic listening purposes. This project was conceived as an inclusive and collaborative platform for artists, scientists and global communities to connect and explore the creative and scientific possibilities of sound and acoustic ecology at a time when it was becoming increasingly critical to listen to the environment.

Biosphere Soundscapes offers a wide spectrum of pathways to engage with the project, from online

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masterclass to hosting interdisciplinary residencies and workshops. The project pivots on a network of site-specific acoustic ecology projects embedded in multi-layered community engagement processes within biosphere reserves. Acoustic ecologists, artists, field recordists, scientists and community members in the biosphere reserve can contribute recordings and soundscapes to a virtual community sound map and collaborate with other locations online via the project website biospheresoundscapes.org. The engagement programs are adaptable and responsive depending on the capacity of the community and accessibility of the environment. Participating biosphere reserves are encouraged to host sound walks, participatory field-recording sessions and acoustic ecology workshops with the support and education resources provided from the Biosphere Soundscapes project team. The project supports remote and developing regions by providing access to the appropriate field recording technology for the community to remain engaged in the ongoing process and continue contributing to the virtual platform.

The Biosphere Soundscapes maps and virtual platform, developed in collaboration with the Australian cultural development agency Feral Arts, is designed to host the sound database and showcase outcomes from the interdisciplinary residencies, which are the core activity in implementing this global project. The sound mapping systems have evolved through various iterations, with the latest system geo-locating recordings in an interactive map with searchable tagging sets. The tags allow listeners and researchers to focus on specific layers of the map, such as aquatic recordings for species identification or interviews with indigenous custodians of the biosphere reserve. The sound maps are also available with timeline features to compare the temporal and seasonal changes in the recordings. This content is all made available and accessible to the local community of the biosphere reserve and in some instances made public online. The community engagement strategies are traditionally delivered as virtual masterclasses that introduce the technology and recording techniques, followed by short workshops and field laboratories that lead towards the development of interdisciplinary residencies. Each residency involves 10-days of immersive field recording with a selected group of participants, theoretical workshops with artists and scientists, and knowledge sharing experiences with the community. The residencies are designed in consultation with the local community with a focus on collaboration, experimentation and exploration and have a balanced engagement with biological and cultural diversity. Residencies have taken place across the Asia-Pacific region and Latin America, including the Sian Ka'an Biosphere Reserve in Mexico.

Sian Ka'an Biosphere Reserve Residency, Mexico 2015

The Sian Ka'an Biosphere Reserve is located in the Mexican State of Quintana Roo on the east coast of the Yucatan Peninsula. The region covers 528,148 hectares of marine, coastal and terrestrial ecosystems making it one of Mexico's largest protected areas. The biosphere reserve was designated by UNESCO in 1986 and received UNESCO world heritage status a year later, in 1987. The biosphere reserve has a rich and dynamic sonic environment with tropical rainforests, underground river systems, mangroves and a diversity of coastal and marine ecosystems. It is home to over 300 species of birds, 42 species of amphibians and reptiles, and wild cats including jaguarundi, jaguar, and pumas. Marine ecosystems include manatee, dolphins, loggerhead, green, hawksbill and leatherback sea turtles and over 52 species of fish. The lagoons and wetlands of Sian Ka'an Biosphere Reserve are home to Morelet's crocodiles, which are monitored through local conservation programs to measure the health of the Sian Ka'an ecosystem.

In 2014, Biosphere Soundscapes partnered with Fonoteca Nacional de Mexico (the Mexican Sound Archive), Amigos de Sian Ka'an and CONANP (National Commission for Natural Protected Areas) to host the inaugural Biosphere Soundscapes residency in Mexico. After one year of research and development, the residency took place in October 2015 in various locations across the Sian Ka'an Biosphere Reserve. The program was designed as an interdisciplinary laboratory focusing on the creative and scientific possibilities of listening and acoustic ecology in Mexico.

The residency call for participation was promoted internationally and received applications from across the world ranging from Hollywood film composers

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interested in expanding their sound design library to marine biology students and anthropologists keen to deepen their engagement with sound studies. The large majority of the applications were from early career researchers who had recently graduated from masters or doctoral degrees and were interested in the possibilities of sound as a tool to understanding the environment. These applicants demonstrated the emerging interdisciplinary interest in this field with proposals from arts, humanities and sciences. These included conservation biologists interested to learn more about acoustic ecology, and composers and field recordists experimenting with the scientific possibilities of their practice. This particular residency application process showed a dramatic increase in applications, which is synchronous with the rapid developments occurring in ecoacoustics, acoustic ecology and sound studies more broadly.

The proposals were reviewed by an international advisory panel and the participants were selected based on their creative or scientist backgrounds, capacity to collaborate and potential to make a contribution to the field. Participants were encouraged to articulate ways they may share their new knowledge, weather through artistic projects, workshops or activating acoustic ecology projects in their own communities after the residency. The selection panel made a conscious decision to achieve a balance between disciplines, experience and geographical locations. While participants are not expected to produce an outcome during the residency, they were encouraged to publish their recordings and research, share the results and act as catalysts to engage other biosphere reserves and communities in the intentions of this project.

The Biosphere Soundscape residency structure involves an intensive 10-day expedition with daily field recording sessions accompanied by interdisciplinary workshops and presentations. In Sian Ka'an, participants explored the biodiversity of the selected recording locations through presentations with local scientists and conservationists from Amigos de Sian Ka'an, the local organisation that manages the biosphere reserve. The residency has a structure that pivots on the daily field recording and thematic dialogues, but it allows flexibility for participants to explore the environment from their personal perspectives and disciplines. Residency participants are welcome to record at any time of the day or night to suit the needs of their interests and proposed projects. However participants are encouraged to join the field recording expeditions with the group. These trips involve travelling to a particular location in the biosphere reserve that has been predefined through the development phase. Once on location, participants divide throughout the landscape, usually with a distance of at least 100 meters between each recordist. Terrestrial recording sessions usually occur at dawn and dusk, while aquatic sessions in freshwater and marine ecosystems occur at various times throughout the day and night. The duration of these sessions range from two to three hours where the recordists will remain in-situ with the equipment, actively listening to the environment while recording.

These recording sessions are followed by discussions where the scientific and aesthetic approaches are investigated. Scientists often approach the dialogue by identifying species, while artists speak of the sonic qualities of the soundscape. The diversity of perspectives quickly reveals the value of listening to the environment with trained ears and the possibilities that arise when artistic and scientific approaches merge. Participants have the opportunity to edit material prior to listening sessions where the group examines recording excerpts and compares equipment, microphone placements and aesthetic approaches. These sessions allow participants to recognise subtle difference in the height and direction of microphone placement and reveal dramatic differences in sound quality between various recording kits. The workshops in Sian Ka'an explored how human perception is a critical element of the field recording process, but questioned how this changed if the recordings were being used for different purposes, such as species identification. It was evident through the workshops, that while recording equipment makes an incredible difference, those with acute listening abilities and trained ears were able to produce compelling listening experiences with low quality equipment. These sessions in Biosphere Soundscapes residencies are designed to allow participants to exchange equipment, ideas and approaches but are underpinned by facilitating deeper collaborations between artists, scientists and communities.

During the Biosphere Soundscapes residencies, the team recognise our presence in the environment has a

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direct impact on the soundscape, the Biosphere Soundscapes residencies also involve a series of remote recording sessions where equipment is left in the field for extended periods to document natural soundscapes without human interference. In these instances, different equipment is used that has the capacity to run for extended periods. These devices are also distributed during community workshops and often left with the community after the residencies. In most instances these include low cost Zoom H2 recorders, which have the capacity for multi-channel recording with four internal microphone capsule that enable various polar patterns including 360-degree surround sound recording. For biosphere reserves interested specifically in the bioacoustics and ecoacoustics approaches, we recommend the installation of devices such as the Frontier Labs Bioacoustic Audio Recorder (BAR) which is accessible for community use and will run for 80 hours of recording without replacing the battery. The device is lightweight, rugged with built in GPS and the ability to schedule recordings for specific durations and times of days. These features are particularly useful to monitor nocturnal wildlife or capturing seasonal changes over extended durations, which could involve recording one minute ever hour over multiple days or weeks. For aquatic recordings, our community kits include Zoom recorders and Aquarian hydrophones (underwater microphones) for non-invasive monitoring and listening in freshwater and marine environments.

Biosphere Soundscapes places importance on the interdisciplinary balance and ensures that equal time is spent on artistic and scientific perspectives in addition to engaging and learning from the community. The design and development of the residency begins first and foremost with establishing a dialogue with local indigenous communities to identify appropriate ways for participants to engage and learn about the biosphere reserve from an indigenous perspective. In the context of Sian Ka'an, this involved a field trip to archaeological sites in Muyil, meetings with community leaders and being introduced to Mayan culture through ceremonies, traditional medicine and local cuisine including Báalche, a drink extracted from the bark of the tree. The residencies engagement with Indigenous perspectives is always guided and designed by the community and adequate space and time is allocated in the programs to prioritise this process. These experiences provide a starting point to explore the notions of knowing a place through sound and the importance of acoustic ecology in the social, cultural and ecological health of a community and environment.

The scientific outcomes of the Sian Ka'an residency were guided by Mexican biologist Sandra Gallo-Corona, who was the lead scientist working with participants during the residency. Following the residency she identified the species in the resulting recordings and assisted in the design of annual monitoring programs for the Sian Ka'an Biosphere Reserve. All the resulting recordings are included in the Fonoteca national sound archive and catalogued for the Biosphere Soundscape community database. In addition to compositions and installations from the participants, the results often inspire a spectrum of other projects, both from the local community and online. Following the Sian Ka'an residency, French sound artist Félix Blume published his resulting recordings on Freesound, a public sound database, which inspired signal processing engineer Dr. Stéphane Pigeon to create a generative online project titled 'A Bird's Paradise: Interactive Tropical Birds Soundscape' using the recordings. This piece was published on Pigeon's website myNoise.net which attracts hundreds of daily users to listen to generative environmental soundscapes.

There has been a diversity of examples where recordings and ideas generated during the residency process have been a catalyst for projects, collaborations and publications. Through the Sian Ka'an Residency, Biosphere Soundscapes facilitated a range of partnerships and collaborations through support from Fonoteca, Mexico's national sound archive and Amigos de Sian Ka'an, the local conservation organisation responsible for managing the biosphere reserve. This process acted as a catalyst for bringing together national arts, humanities, environmental management and conservation organisations that would not usually have the opportunity to interact or collaborate. While this is just one residency example, this case study demonstrates the process of developing, designing and delivering a Biosphere Soundscapes residency and the diversity of possible outcomes.

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Conclusion

Biosphere Soundscapes draws on emerging science, indigenous knowledge systems and responsive community engagement to explore the social, cultural and ecological soundscapes of biosphere reserves. The multi-platform nature of the project has the capacity to function at micro and macro levels and facilitate long-term partnerships and collaborations. The interdisciplinary possibilities of sound are prevalent in other likeminded initiatives such as Ear to the Earth in New York City or Matthew Burtner EcoSono (ecosono.com) activist network designed to advocate environmental preservation through experimental sound art. There is a dramatic increase in composers and sound artists engaging with interdicipinary practice across the world, including Italian composer David Monacchi's Fragments of Extinction project initiated with the intention of recording the world's undisturbed primary equatorial forests to highlight the disappearing soundscapes of nature (Monacchi 2013). The project has evolved into a non-profit organisation that works in collaboration with artists, scientists and sound engineers to produce immersive installations and shares many similarities with Biosphere Soundscapes both in intention and approach.

Acoustic recordings of the environment provide a viable means to understand and document the temporal and spatial complexities of changing ecosystems through non-invasive technology. While standardised techniques for automated species identification or analysing acoustic complexity as a proxy for biodiversity are still developing, the rapid increase of engagement and research in the last five years suggests this field will continue to expand and evolve. The future potential of Biosphere Soundscapes revolves around the digital platform and sound map that encourages biosphere reserves across the world to contribute, connect and engage. In the future, this platform will enable live streaming tools, the ability to mix soundscapes in real time and host an array of analysis tools and creative projects.

Biosphere Soundscapes combines artistic perspectives, emerging science and new technologies to work directly with local and global communities in highlighting the changing soundscapes of UNESCO biosphere reserves. The resulting soundscapes continue to provide a valuable scientific database, while at the same time offering infinite possibilities for creative interpretations. These artistic works are designed for global engagement to create experiences of being present and immersed in UNESCO biosphere reserves. The creative outcomes are disseminated at international events and realised as performances, installations and augmented reality experiences. Recent examples include Rainforest Listening (rainforestlistening.com), an augmented reality installation layering the tropical rainforest soundscapes of the Central Amazon Biosphere Reserve in urban environments across the world. Rainforest Listening launched in September 2015 in the centre of Times Square with an augmented reality sound walk that mapped the Amazon Rainforest to New York City as a featured event for Climate Week NYC 2015. Rainforest Listening was also featured at COP21 in Paris where the Eiffel Tower and surrounding parklands were transformed into an immersive sonic experience of the Central Amazon Biosphere Reserve. Each observatory platform of the Eiffel Tower was interpreted as the four distinct layers of tropical rainforest vegetation through immersive soundscapes. The touring creative outcomes from Biosphere Soundscapes are critical factors for public awareness and provide immersive, sensory experiences to inspire connection and engagement with major ecosystems across our planet.

Biosphere Soundscapes is designed to be accessible, adaptable, inclusive and responsive to the diversity of locations in the World Network of Biosphere Reserves. The project is currently working with fourteen locations with a vision to map the changing soundscapes of 100 biosphere reserves over the next decade. The communities of biosphere reserves are welcome to contribute and collaborate and can explore various pathways available on the project website www.biospheresoundscpaes.org. Artists, scientists and researchers are encouraged to engage through workshops, residencies and our international internship program. Biosphere Soundscapes is designed to expose the creative and scientific possibilities of listening to the environment and position acoustic ecology as an inclusive interdisciplinary field that can assist in understanding the rapid social, cultural and ecological changes taking place across the globe.

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Bioregions vs. Biosphere Reserves: Which is a Better Vehicle for Sustainability?

Don Alexander, Geography Department/ Master of Community Planning Program Vancouver Island University
900 Fifth Street, Nanaimo, BC V59 5S5 Canada

Email: Don.Alexander@viu.ca

ABSTRACT: In the past fifty years, various concepts have emerged that have the potential to assist societies in achieving greater sustainability. In this article I will briefly review the evolution of the bioregion and biosphere reserve concepts, look at definitional issues, at their similarities and differences, and at their relative strengths and weaknesses as vehicles for promoting the greater sustainability of human societies.

Keywords: biosphere reserves, bioregions, sustainability, sense of place, Mount Arrowsmith Biosphere Region

In the past fifty years, various concepts have emerged that have the potential to assist societies in achieving greater sustainability. In this article I will briefly review the evolution of the bioregion and biosphere reserve concepts, look at definitional issues, at their similarities and differences, and at their relative strengths and weaknesses as vehicles for promoting the greater sustainability of human societies. While the notion of bioregion has certain antecedents, it is marginally newer. Therefore, I will review the evolution of the biosphere reserve concept first.

The Origin of the Biosphere Reserve Concept

The key milestones in the evolution of the biosphere reserve concept will be well-known to readers of this journal. In 1968, the United Nations Educational, Scientific and Cultural Organization (UNESCO) convened a conference of thought-leaders in Paris to discuss the challenge of how to create greater harmony between humans and their environment. Two years later, the Man and Biosphere (MAB) program was established, which sought amongst other things to create areas where biodiversity could be preserved and protected as representative segments of the earth's biomes and ecosystem types, including coastal areas. The biosphere reserve concept was officially christened in 1974, with the first designation occurring in 1976. (Coetzer, Witkowski, & Erasmus, 2013) The reserves were to be characterized by a core zone of protection, by a buffer area where scientific research and education activities would be carried out, and by a transitional zone where more intensive sustainable practices were to be modelled. To quote MAB, "Each biosphere reserve is intended to fulfill three basic functions, which are complementary and mutually reinforcing:

- a conservation function - to contribute to the conservation of landscapes, ecosystems, species and genetic variation;
- a development function - to foster economic and human development which is socio-culturally and ecologically sustainable;
- a logistic function - to provide support for research, monitoring, education and information exchange related to local, national and global issues of conservation and development." (UNESCOa, n.d., n.p.)

In the last 50 years, a number of such reserves have been created in 120 countries, while at the same time others have been withdrawn. The current total stands at 169. Reserves are nominated by nation-states or at least with their tacit approval. (UNESCOb, n.d.) Once accepted by UNESCO, they are subject to review every ten years. In theory, core areas are supposed to enjoy legal protection, but I have yet to find evidence that this is actually enforced. In many cases – as with Canada's Waterton Lakes Park or the Niagara Escarpment – they already enjoy some legal status nationally or provincially. (Reed 2010) Whatever jurisdictional status and protection

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designation as a biosphere reserve confers is in the realm of what has been called 'soft law' – i.e. without binding authority. (Reed, 2010) Since its initial establishment, MAB has also added objectives related to the UN's *Sustainable Development Goals* and *Post 2015 Development Agenda*. In Canada we have 18 such reserves, including two in British Columbia, both on Vancouver Island. (Canadian Biosphere Reserves Association, n.d.)

The Origin of the Bioregion Concept

The concept of bioregion and associated bioregionalism, while having antecedents, was first popularized in the mid-1970s by Peter Berg and Raymond Dasmann of the Planet Drum Foundation, an organization founded in 1974 to "pursue research and publish information on the relationship between human culture and the natural processes of the planetary biosphere." (Berg, 1983, p. 19) Berg was a longtime member of the California counterculture, and Dasmann, a noted ecologist, was a leading member of the International Union for Conservation of Nature and Natural Resources. (Alexander, 1990)

The word bioregionalism appears to have been coined by a Canadian, Allen Van Newkirk, in 1974 in a research prospectus entitled "Bioregions: Towards Bioregional Strategy for Human Culture." This prospectus first appeared in the Union's journal, *Environmental Conservation*, and was reprinted in *CoEvolution Quarterly*. Peter Berg likely picked up the term from Dasmann or from *CoEvolution Quarterly*. (Parsons, 1985)

That the idea was ready to be born is shown by the appearance in 1974 of Ernest Callenbach's bioregional novel, *Ecotopia*, about an ecological nation in northern California, Oregon, and Washington which secedes from the United States. (Callenbach, 1974) A couple of years later, David Haenke (1987), a future bioregional author and activist, began making plans for holding an Ozark Community Congress, the first bioregional gathering of its kind. Kirkpatrick Sale (1985, p. 43) offers perhaps the most concise definition of a bioregion as being "a place defined by its life forms, its topography and its biota, rather than human dictates; a region governed by nature, not legislature."

Bioregionalists believe that nation-states and other administrative divisions are artificial. As Bice Wilson (1995, p. 18) notes,

We often define our communities on the basis of human boundaries, such as national borders, property lines, school districts, town boundaries, area codes, zip codes, government service districts, and zoning districts. These confusing service zones are often invisible and overlapping yet seldom connected, and not even based on geography.

In contrast with modem industrial society which effectively alienates people from the land, bioregionalists advocate "living-in-place," which means "following the necessities and pleasures of life as they are uniquely presented by a particular site, and evolving ways to ensure long-term occupancy of that site." (Berg & Dasmann, 1987, p. 217) They argue that "Living-in-place is an age-old way of existence disrupted in some parts of the world a few millennia ago by the rise of exploitative civilization, and more generally during the past two centuries by the spread of industrial civilization." Berg & Dasmann, 1987, p. 217) Bioregionalism, in essence, is the regional fulfillment of Aldo Leopold's 'land ethic.' As Stephanie Mills writes, "In a bioregion, the citizenry is more than human. Bioregionalism goes beyond ecology, in its enfranchisement of other life forms and land forms, and its respect for their destinies as intertwined with ours." (Mills, 1981, p. 4) Thirty-two years before Mills, in 1948, Aldo Leopold had written that

The land ethic . . . enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land. In short, a land ethic changes the role of Homo sapiens from conqueror of the land-community to plain member and citizen of it. (Leopold, 2014, pp. 25-26)

The process of becoming an ecological citizen is described by Berg and Dasmann as "reinhabitation":

Reinhabitation means learning to live-in-place in an area that has been disrupted and injured through past exploitation. It involves becoming native to a place through becoming aware of the particular ecological relationships that operate within and around it. It means understanding activities and evolving social

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behavior that will enrich the life of that place, restore its life-supporting systems, and establish an ecologically and socially sustainable pattern of existence within it. Simply stated it involves becoming fully alive in and with a place. It involves applying for membership in a biotic community and ceasing to be its exploiter. (Berg & Dasmann, 1987, pp. 217-218)

Boundary Demarcation

From I have been able to determine, there is no one formula for determining the boundaries of biosphere reserves. In theory, biosphere reserves were to serve as 'model regions' "where people are living and working well together and in harmony with nature." (MABRa n.d.; MABRRI, n.d.,n.p.) Moreover, there were originally to reflect the global distribution of biogeographical provinces, as defined by Miklos Udvardy (1975), and to provide scientists with a 'living laboratory' for studying ecological processes. (Reed & Massie, 2013) In the case of the Mount Arrowsmith Biosphere Reserve case (since redubbed Biosphere 'Region'), now managed in partnership with Vancouver Island University, the nomination process was originally launched in 1996 by Dr. Glen Jamieson to "raise awareness of the biodiversity of watersheds on Mount Arrowsmith and adjacent watersheds." (MABRa, n.d., n.p..) Was this a 'model region' of human/ nature harmony, or rather one where the process of degradation was not sufficiently advanced such that it made it sense to try to rescue it while the opportunity still existed?

Do biosphere reserves have an 'organic' unity? MABR is described as comprising "five watersheds: Englishman River, Little Qualicum, French Creek, Nanoose Creek, and Bonnel Creek." (MABRb, n.d.) Why these particular adjacent watersheds? Presumably because they run off Mount Arrowsmith, the major landmark in the area. The region is also said to share "similar boundaries with the Regional District of Nanaimo." (MABRb, n.d.) Actually, the boundaries of the two entities, while overlapping, do not coincide that closely (see Map 1).

More recently – in the last twenty years – biosphere reserves have come to emphasize social learning by a variety of stakeholders, not just scientists, and social science research has come to occupy a more prominent role than in the past. (Reed & Massie, 2013) Moreover, in the wake of the Brundtland Commission report, *Our Common Future*, operationalizing and modeling 'sustainable development' has become a major theme. (Reed & Massie, 2013) This is certainly true in the Mount Arrowsmith Biosphere Region.

Bioregions, for their part, can be defined by any number of criteria. Natural regions include *physiographic* criteria, such as the Salish Sea/ Puget Sound depression (see Map 2) or even major islands, such as Vancouver Island; *vegetational* (such as Coast Douglas Fir zones), and *hydrological*, such as watersheds of varying sizes. These natural criteria almost always conflict with one another. (Alexander, 1993, p. 4)

One can also choose human regions, though this is done less frequently. For instance, there are *political* regions at a variety of scales – provinces, regional districts, and municipalities; *economic* regions, which can be defined in terms of commutersheds, urban shadow zones (areas affected by inflated urban real estate values, or areas served by major retail services, such as destination malls or media outlets), and *cultural* regions, such as the area occupied by the Halkomelem-speaking Coast Salish First Nations people or senses of place determined by distinctive settlement and land use histories, such as southern vs. northern Vancouver Island. All of these boundaries are quite graduated rather than hard and fast. Again, they do not often correspond with one another or with natural regions, although in the case of the Coast Salish peoples this does roughly correspond with the watersheds that drain into the Salish Sea (see Map 2), with the exception of the Fraser basin which, in its entirety, encompasses a quarter of the province of British Columbia. (Alexander, 1993) In addition to this, some bioregionalists refer to 'terrain[s] of consciousness" and 'spirit places.' – i.e. that bioregions exist where people *think* they exist. (Carr, 2004, p. 76)

Ideally, one would choose the best compromise between criteria or, alternatively, something that is clear cut such as watershed boundaries. Of course, such (bio)regional boundaries exist at a variety of scales – the *subcontinental*, such as Cascadia (defined by the temperate rainforest or Pacific salmon zone); the *bioregional* (the Salish Sea/ Georgia Basin); the *regional* (the Lower Fraser Basin or southern or northern Vancouver Island), or the *local* (a watershed

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or regional district/ urban-centred area). (Alexander 1990) I myself prefer the local, as it is the area which seems to possess the strongest sense of place and popular identification.

An example of a local area would be the Cowichan Valley, which in addition to being a watershed, also possesses a variety of distinctive microclimates (often dubbed 'Mediterranean') that enable the cultivation of a diverse array of agricultural products. It possesses a strong sense of place and identification. The watershed includes major centres like Duncan, and an expanded definition of the 'river valley' or coastal plan includes communities such as Crofton and Chemainus. (Wikipedia, 2016) However, the regional district of the same name, while overlapping, does not correspond that closely with the watershed after which it is named (see Map 3).

Similarities and Differences

Both concepts have a strong emphasis on biophysical factors and seek to celebrate and enhance ecological functioning and the sustainable integration of human activities into the region; however, traditionally, bioregions have lacked the focus on scientific research. Biosphere reserves have a stronger focus on having protected core areas. In theory, reserves are based on definable biophysical features, but how their boundaries are chosen seems somewhat idiosyncratic; there is no formula despite reference to Udvardy's nomenclature in the early days. Nomination was often opportunistic and often based on existing protected areas (Reed & Massie, 2013). Administratively, they are governed – if at all – through consensus, i.e., through collaboration between stakeholders through roundtables and with the moral authority of the UNESCO designation, or by the authorities that normally govern the corresponding national or sub-national park or protected area.

Bioregions have *no* administrative authority or legitimacy, although occasionally governments have referred to large-scale bioregions, or some loose facsimile thereof – such as Cascadia – for limited purposes, such as economic cooperation, action on climate change, or conservation measures around salmon. (Brunet-Jailly, 2005) Despite a promising start as a social movement, bioregions do not have much to show on the ground in contrast with biosphere reserves.

Strengths and Weaknesses

The strength of biosphere reserves is that they enjoy recognition from a larger body – UNESCO. UNESCO has no ultimate authority beyond the ability to cancel a reserve after an unfavourable 10-year review. Ultimately, nation-states determine their fate, and a number have been withdrawn over the past 40-plus years. Even where they are still in existence, how well they are managed and with what degree of integrity is entirely up to national and sub-national jurisdictions, including biosphere reserve foundations and roundtables. Nonetheless, biosphere reserves seem to have the potential to foster the same ethic of 'reinhabitation' advanced by the bioregionalists.

In theory, bioregions have an organic unity that biosphere reserves may lack. However, bioregions have no authority whatsoever and are only as good as the popular allegiance they foster. This, in an age when globalization and consumerism is overtaking notions of citizenship of any description, tends to be limited.

Conclusion

Much more research needs to be conducted on the degree of affinity residents feel for biosphere reserves, but my fear is that they lack an 'organic' sense of place attachment, something that the Cowichan Valley, for instance, possesses. Certainly, it's not clear to me that the Mount Arrowsmith Biosphere Reserve/ Region makes natural 'sense' to the people who live there, though the Mount Arrowsmith Biosphere Region Research Institute (MABRRI) is doing its best to educate people about its value and to build up that affinity, including through its call to have people nominate "Amazing Places" throughout the Region (MABR, 2016). The extent to which a region – be it a bioregion or biosphere reserve/region – can serve as a vehicle for creating a more sustainable society and more sustainable land and water use patterns and practices is a question that can only be answered in practice. If it achieves the desired effect, that is ultimately what counts. As the old saying goes: "run it up the flagpole and see if anyone salutes."

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It would be useful, in further research, to focus on the degree of place attachment experienced by residents of biosphere reserves *and* bioregions and, with the latter, to discover what scale is the most effective for achieving this. Also, it would be worth looking at the extent to which each has been an effective focus for local/ regional sustainability efforts through a comparative study of cases. To do so, one would need clear criteria as to how sustainability is to be defined, its relevant dimensions, and who the agents of change are considered to be.

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Shared Values, Shared Success: Remediating Endangered Lamprey Habitat in British Columbia

Joy Wade Fundy Aqua Services Inc.
1859 Delanice Way, Nanoose Bay, BC, V9P 9B3

Email: Joywadefundyaqua@gmail.com

Sean MacConnachie Fisheries and Oceans Canada
3190 Hammond Bay Rd., Nanaimo, BC, V9T 9B3

Email: Sean.MacConnachie@dfo-mpo.gc.ca

ABSTRACT: Stream remediation was undertaken at two impassable fish obstacles in Morrison Creek in Courtenay, British Columbia. These barriers were identified as impassable to the endangered Morrison Creek lamprey (*Lampetra richardsoni* variety *marifuga*) and a seasonal impediment to the movement of salmonids. The success of this remediation was not only in the removal of barriers to lamprey but in balancing the needs of multiple species of differing and sometimes conflicting habitat requirements. Community engagement was also a key outcome of the remediation with increased awareness of the protected lamprey species, hands-on interaction with stream remediation activities and the interaction and cooperation with landowners. What remains to be determined is if these remediation activities can slow or reverse the decline observed in catches of Morrison Creek lamprey.

Keywords: Lamprey; habitat; endangered species, British Columbia

In Courtenay, British Columbia in a small creek approximately 24 km long (Wade et al. 2015) exists a biological enigma (Beamish et al. 2015), the Morrison Creek lamprey (*Lampetra richardsoni* variety *marifuga*). This small, 114-124 mm (silver form) (Beamish 2013) parasitic lamprey is a distinct form of the western brook lamprey (*Lampetra richardsoni*) found only in Morrison Creek and its tributaries (National Recovery Team for Morrison Creek Lamprey 2007). It has been proposed by Youson (2004) that Morrison Creek lamprey may represent a step in the evolution of lampreys. One explanation may be that Morrison Creek lamprey is an intermediate stage in the evolution of *L. richardsoni* from the parasitic anadromous *L. ayresii* (Wade & Beamish 2014). Understanding Morrison Creek lamprey may lead to the understanding of how lamprey have survived for over 300 million years.

The extreme endemism and a unique life history led this animal to being assessed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1995 and its subsequent protection under Canada's Species at Risk Act (SARA) (National Recovery Team for Morrison Creek Lamprey 2007).

Morrison Creek lamprey inhabit an urban creek which is supplied water through underground sources located in the headwaters of Morrison Creek (Wade et al. 2015). It is believed these underground sources may include bodies of water such as Comox Lake, First Supply Creek and Nellie Creek (Wade et al. 2015). This urban creek is not unlike other urban bodies of water; it is bordered by private land, parks, schools and industrial sites. The Morrison Creek watershed is home to a diversity of species including large mammals such as black bear (*Ursus americanus*) and Roosevelt elk (*Cervus elaphus roosevelti*), amphibians and crustaceans, most notably signal crayfish (*Pacifastacus lenisculus*) (Wade et al. 2015). In addition to western brook lamprey (*L.*

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richardsoni) and Morrison Creek lamprey, fish species present in Morrison Creek include Pacific lamprey (*Entosphenus tridentatus*), coho salmon (*Onchorhynchus kisutch*), pink salmon (*O. gorbuscha*), chum salmon (*O. keta*), cutthroat trout (*O. clarkii*), rainbow trout (*O. mykiss*) and threespine stickleback (*Gasterostreus aculeatus*) (Wade et al. 2015). It is believed this complex environment has somehow provided for the existence of Morrison Creek lamprey, what conditions they may be are unknown, however, what we can describe are the current physical and biological conditions.

Although Morrison Creek lamprey were first discovered in the late 1970s and first described in 1987 (Beamish 1987) no research was conducted again until 2011. Little is known about the abundance of lamprey in Morrison Creek however based on differences in catch rates from trapping activities from the late 1970s to the late 1980s compared to similar trapping activities in 2011 and 2012, catch rates have declined (Wade & Beamish 2014; Beamish 2013). Understanding that there are many single and cumulative reasons for the decline in any fish population compounded by the fact that we do not know what regulates the expression of the Morrison Creek lamprey form , limiting factors associated within the watershed were explored. Physical barriers to fish movement with the potential for habitat fragmentation were discovered in several locations (Wade & Beamish 2014). As the negative effects of habitat fragmentation or discontinuity on anadromous or potamodromous fish species can range from disruption of migration to localized extinction (Beamish & Northcote 1989; Baras & Lucas 2001; McLaughlin et al. 2006) the remediation of the barriers was recommended and undertaken.

Two barriers, a hung culvert and a defunct salmon weir (Figure 1a, b respectively) were identified as impassable by Morrison Creek lamprey (Wade & Beamish 2014). Because these lamprey reside in an environment which is important to multiple species which would benefit from remediation of these barriers, funding was requested from various sources. Funding was secured from three sources: Environment Canada's Habitat Stewardship Program (HSP) for species at risk, the Habitat Conservation Trust Fund (HCTF) and British Columbia Hydro's Fish and Wildlife Compensation Program (FWCP). In addition, in-kind contributions were made by Island Valley Farms, Timberwest, Fisheries and Oceans Canada, Fundy Aqua Services Inc. and the Morrison Creek Streamkeepers. In 2015, stream remediation activities were undertaken in early fall (Figure 2a,b), recognizing the need to take into consideration the ecological sensitivities of both spawning lamprey and returning pink salmon.

The project has proven to be a success in many ways. An incredible amount of community involvement and engagement resulted from this work with volunteers of all ages ready andwilling to commit hands-on time to the rehabilitation work. There was the cooperation of local residents through access to land and engagement of individuals and funders via guided watershed walks. This remediation project has provided a platform to increase awareness of a protected species as well as the importance of balancing the needs of multiple species (including humans) in a complex ecosystem.

Physically, sensitive areas of the river have now been ameliorated which will aid in reducing sedimentation, an issue of high importance for salmonids. Within days of completing the remediation work, pink salmon were observed swimming up Morrison Creek and were found in the upper headwaters where they had not been seen before by local residents (Jim Palmer, Personal Communication 2015). The next measure of success will be to determine if lamprey can move freely within their range and whether these efforts can slow or reverse the decline in numbers as observed through trapping.

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Figure 1: Photograph of impassable barriers to Morrison Creek lamprey taken in spring 2013.

Pictured left: Hung-culvert

Pictured right: Defunct salmon weir

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Figure 2: Photographs of remediated areas of Morrison Creek (fall 2015).

Picture above: Remediated culvert

Picture below: Remediated location of salmon weir.

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Identification of Range Extent of the Morrison Creek Lamprey (*Lampetra richardsoni* var. *marifuga*) in Canada

Sean MacConnachie, Fisheries and Oceans Canada
3190 Hammond Bay Rd., Nanaimo, BC, V9T 9B3

Email: Sean.MacConnachie@dfo-mpo.gc.ca

Joy Wade, Fundy Aqua Services Inc.
1859 Delanice Way, Nanoose Bay, BC, V9P 9B3

Email: Joywadefundyaqua@gmail.com

Mike Waters, Fisheries and Oceans Canada
Suite 1530-401 Burrard St. Vancouver, BC V6C 3S4

ABSTRACT: In 2014, preliminary surveys were undertaken to assess the extent of distribution of lamprey in the headwaters of Morrison Creek in Courtenay, BC. In support of the identification of critical habitat of Morrison Creek lamprey (*Lampetra richardsoni* var. *marifuga*), further studies were undertaken in June and July 2015 to determine if adult lamprey were present in the headwaters. Until this time, they had only been observed in the main stem of the creek. Over the 23 days of trapping, 176 lampreys were caught and measured, 15 of which were adult *L. richardsoni* variety *marifuga*. This information confirms the increased expansion of the previously reported distribution of *L. richardsoni* variety *marifuga* within the Morrison Creek watershed.

Keywords: lamprey, conservation, range, distribution, Morrison Creek

Introduction

Morrison Creek lamprey, *Lampetra richardsoni* variety *marifuga* are present only in Morrison Creek in Courtenay, British Columbia (National Recovery Team for Morrison Creek Lamprey 2007); it is a variety of western brook lamprey (*L. richardsoni*). In 1995, this species was assessed as Endangered by COSEWIC and is currently protected under the Canadian *Species at Risk Act* (SARA). Very little information is known about the biology, status and extent of range of this population of lamprey. However, in recent years, efforts have been made to address some of these basic science questions and inform the protection and management of the population as reflected in the recovery strategy (National Recovery Team for Morrison Creek Lamprey 2007), specifically, the determination of abundance and distribution of the species.

In 2014 and 2015, in conjunction with Hancock Forest Management, surveys were undertaken to begin determining the extent of distribution of lamprey in the headwaters of Morrison Creek; specifically within the company's property (Wade and MacConnachie 2014). Previous surveys focused on areas of the creek within the city of Courtenay with limited efforts elsewhere (Beamish 1987, Beamish 2013, Wade and MacConnachie 2014).

In 2014 passive milk crate traps (Wade and MacConnachie 2014) were installed and monitored on Hancock Forest Management land for ammocoetes and recently metamorphosed lamprey. Because it is not possible to distinguish between *L. richardsoni* and *L. richardsoni* var. *marifuga* at either of these stages, areas identified as successful trapping locations in 2014 were further studied in 2015 using a different type of trap in order to determine if *L. richardsoni* var. *marifuga* were present in this headwater region.

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Methods

Following the methods described in Wade and MacConnachie (2014) three in-stream, flow through traps were installed in the upper reaches of Morrison Creek. All traps were installed in the main stem of Morrison Creek (Figure 1) and contained HOBO TidbiTv2 temperature data loggers to record water temperatures. Trap site selection required the presence of a mix of sandy/silty habitat where the trap could be buried in the sediment, such that the inflow pipe was submerged. Moderate stream flow is required to move fish toward the mouth of the intake pipe. Traps were installed in early summer when *L. richardsoni* var. *marifuga* are known to be in or near spawning condition (Beamish 2013).

Traps were checked daily until their removal on July 6, 2015. Traps were removed earlier than planned due to extreme fire hazard and drought conditions. Any non-lamprey species were identified, enumerated and released downstream of the trap. Lamprey were removed from the trap with a small dip net and placed in an anesthetic bath (100-125 ppm tricaine methanesulfonate). Once fish were sedated, they were removed from the bath, identified (*L. richardsoni* or *L. richardsoni* var. *marifuga*), identified to stage of development, and measured for total length. After sampling, they were placed in a recovery bucket with creek water. Once completely recovered they were returned to the creek, downstream of the trap.

Results

Three traps were fished for a total of 69 trapping days from June 13 to July 6, 2015 (Figure 2). A total of 176 lamprey were captured (Table 1), 156 *L. richardsoni*, 5 ammocoetes and 15 *L. richardsoni* var. *marifuga*. Lamprey were captured each day throughout the sampling period (Figure 2).

	Trap 1	**Trap 2**	**Trap 3**	**Total**
L. richardsoni	13	138	1	152
L.richardsoni var. *marifuga*	4	11	0	15
Ammocoete	2	1	2	5
Total	19	150	3	172

Table 1: Lamprey catches in the headwaters of Morrison Creek in 2015.

L. richardsoni var. *marifuga* ranged in length from 9.8 to 15.6 cm (N=15) and a mean of 12.06 cm (Figure 3). *L. richardsoni* ranged in length from 8.9 to 14.5 cm (N=156), mean length of 11.17cm. Ammocoetes ranged from 6.2 to 11.6 cm in length (N=5), with mean of 9.4cm.

Discussion

This survey was undertaken to determine the presence and extent of the range of *L. richardsoni* var. *marifuga* in the headwaters of Morrison Creek. This information is important in that it increases our knowledge of distribution of *L. richardsoni* var. *marifuga* within the Morrison Creek watershed that was previously only known to occur in the lower reaches of the creek within the boundary limits of the city of Courtney. The results will inform Hancock Forest Management land planning. This work also supports the recent recommendations for critical habitat for this species (Wade et al 2015).

Acknowledgments

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Figures

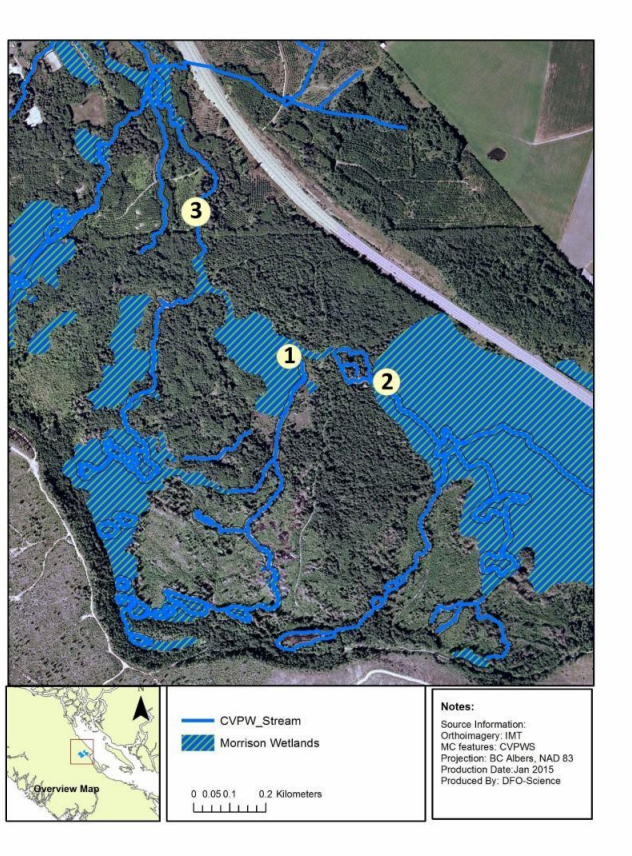

Figure 1: Trap locations in the Morrison Creek headwaters within Hancock Forest Management property for the 2015 survey. Traps identified as 1-3 corresponding to results presented in Table 1.

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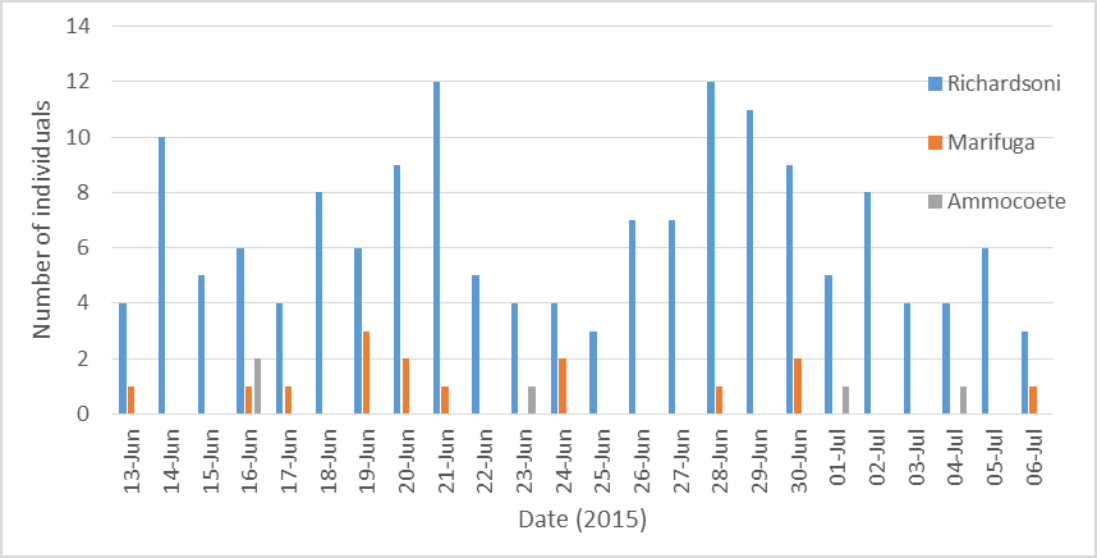

Figure 2: Daily capture rates of *L. richardsoni*, *L. richardsoni* var. *marifuga* and ammocoetes in Morrison Creek headwaters in 2015.

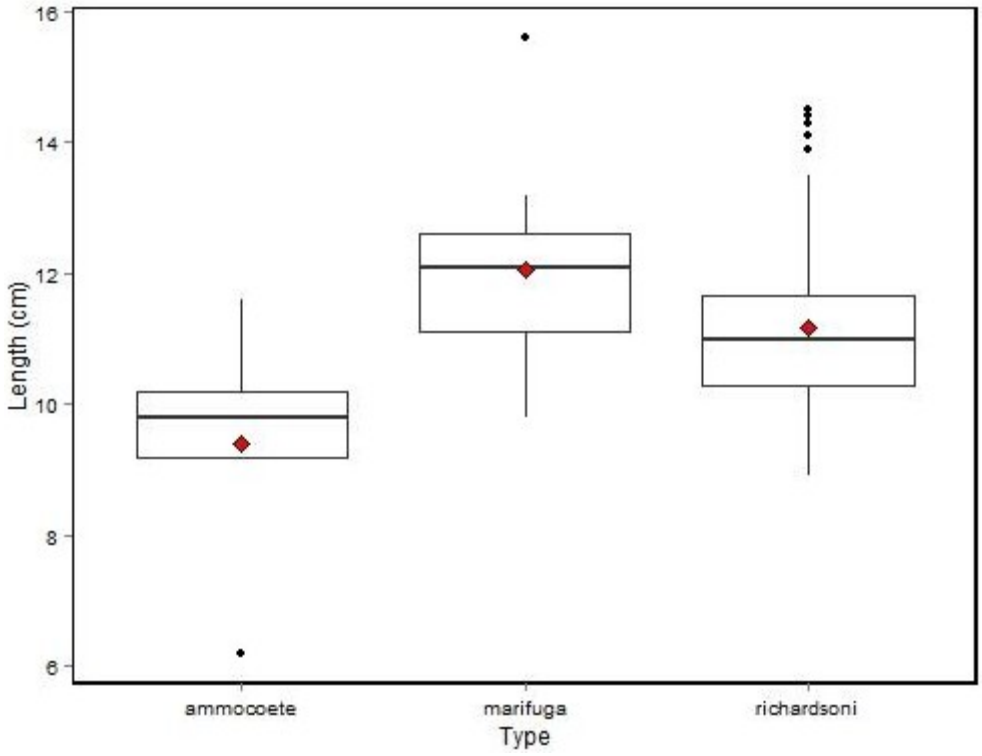

Figure 3: Length distribution of *L. richardsoni var. marifuga* , *L. richardsoni* and ammocoetes from the headwaters of Morrison Creek 2015. Red diamond= mean, black lines in the boxes show the median, upper and lower limits of boxes represent 75th and 25th percentiles respectively, whiskers represent highest and lowest values within the 75th and 25th percentiles, and dots are outliers.

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