Material Culture Review

Learning experiences about intangible heritage conservation for sustainability in biosphere reserves

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Volume 82-83, 2015–2016

URI : https://id.erudit.org/iderudit/mcr82_83art07

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Éditeur(s)

Cape Breton University Press

ISSN

1718-1259 (imprimé)
0000-0000 (numérique)

Découvrir la revue

Citer cet article

Karez, C. S., Hernández Faccio, J. M., Schüttler, E., Rozzi, R., Garcia, M., Meza, Á. Y. & Clüsener-Godt, M. (2015). Learning experiences about intangible heritage conservation for sustainability in biosphere reserves. *Material Culture Review*, *82-83*, 84–96.

Résumé de l'article

Cet article présente des études de cas de différentes approches du développement durable réalisées sous l'égide du Réseau mondial des réserves de biosphère de la division Homme et biosphère de l'UNESCO en Amérique latine et dans les Caraïbes. En 2012, l'Amérique latine et les Caraïbes possédaient 116 réserves de biosphère désignées dans 21 pays. Dans cette région, plusieurs réserves de biosphère ont mis en œuvre d'importantes actions de gestion visant le développement durable en conservant les services écosystémiques et biodiversité. UNESCO 2006; 2008). Ces études de cas mettent en lumière les bonnes pratiques concernant l'usage qui est fait du savoir traditionnel par la recherche et l'enseignement scientifiques en vue de la conservation de la diversité culturelle et biologique au bénéfice des communautés locales et autochtones. Elles se concentrent sur l'amélioration du savoir écologique unique de ces communautés du cap Horn (Chili) et de la réserve Bosawas (Nicaragua) ainsi que, dans les Caraïbes, de la Sierra del Rosario et de la Cuchillas del Toa (Cuba). En outre, elles explorent et renforcent les liens entre la diversité culturelle et la diversité biologique dans ces sites exceptionnels par le biais du savoir local et autochtone pour la gestion durable de ces sites.

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Résumé

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Abstract

This paper presents case studies on different approaches to sustainable development carried out in the UNESCO MAB (Man and Biosphere) World Biosphere Reserve Network in Latin America and the Caribbean. In 2012, Latin America and the Caribbean had 116 biosphere reserves designated in 21 countries. In this region several biosphere reserves have implemented important management actions towards sustainable development by conserving ecosystem services and biodiversity (UNESCO 2006; 2008). These case studies highlight good practices on the use of traditional knowledge by scientific research and education for cultural and biological diversity conservation to the benefit of local and Indigenous communities. They focus on improving recognition of the unique ecological knowledge of these communities in Cabo de Hornos (Chile) and Bosawas (Nicaragua), and in the Caribbean: Sierra del Rosario and Cuchilla del Toa (Cuba). Moreover, they explore and reinforce the links between biological and cultural diversities in these outstanding sites, through local and Indigenous knowledge for the sustainable management of those sites.

Biosphere Reserves as Models of Sustainable Development

Biosphere reserves are designated at international level by UNESCO's Man and the Biosphere Programme (MAB). Candidacies are submitted by each country to become part of the World Network of Biosphere Reserves. The first biosphere reserves were declared in 1976 and by 2013 there were 621 sites in 117 countries. The world network has been regulated since 1995 by a statutory framework which establishes the criteria for MAB-ICC (International Coordinating Council) to designate a biosphere reserve according to its article 4 (UNESCO 1996).

The Seville Strategy and the Statutory Framework (ibid.) improved the application of the concept, created a periodic review of biosphere reserves every ten years and defined indicators for follow-up on the functioning of sites and the World Network (ibid.).

Biosphere reserves differ from UNESCO Word Heritage sites, which are declared because of their outstanding universal natural and/or cultural values. Biosphere reserves are sites

for learning about sustainable development as outlined by the targets of the Madrid Action Plan for Biosphere Reserves (UNESCO 2008b). Their management takes into consideration ecological, social, cultural, economic, and political characteristics at local level. Target 19 of the Madrid Action Plan, aims at mobilizing all knowledge systems to reinforce the research programs directed toward ecosystem services provided by biosphere reserves. Local and Indigenous ecological knowledge are increasingly considered in the management of some biosphere reserves. However, there is relatively little research on learning and applying local and Indigenous knowledge in biosphere reserves management. Most studies are specific to certain areas of knowledge such as ethno-botany.

Each biosphere reserve has a zonation system, containing three main zones: core, buffer, and transition, which are delimited based on scientific data as well as stakeholder participation. The core areas are dedicated to biodiversity protection, regulated by national or local legislation, the buffer areas are sustainable use zones, and the transition zones are areas where sustainable practices and policies are being tested. This latter zone is also known as a cooperation zone because participatory management actions are being undertaken.

According to the Madrid Action Plan, all three zones should be integrated: core zones should also be considered development sustainable zones because of the ecosystem services they provide to the communities that live near the core areas and benefit from their conservation. Practices and policies for the sustainable management of natural resources should be financed in transition zones through cooperative partnership plans among public and private sectors. In buffer zones both functions—conservation and development—are maintained and integrated through activities carried out by local communities.

Latin America and the Caribbean have set up a network named IberoMAB (Ibero-American Man and the Biosphere Network) which also includes Spain and Portugal. The Network has facilitated an intensive exchange of information and enhanced the capacity building of biosphere reserve managers (IberoMAB 2010). Examples of good practices are presented in Araya and Clüsener-Godt (2007). Another example of cooperation involves the Amazon biosphere reserves which are coordinated by the UNESCO Chair for South-South Cooperation for Sustainable Development in the Federal University of Para, in Brazil (Aragón and Clüsener-Godt 2008). These activities are co-ordinated by the UNESCO Division of Ecological and Earth Sciences in collaboration with the UNESCO Regional Science Bureau and the technical and financial support of the Spanish Autonomous National Parks Organism.

The management committee for each biosphere reserve, comprising scientists, politicians, park administrators, etc., establishes a participatory management plan that includes the main stakeholders, in particular, local and Indigenous communities (UNESCO 2008b). The notion of community participation is central to biosphere reserves because local actors can participate in decision-making regarding their management (Stoll-Kleemann et al. 2010). In order to achieve the above-mentioned objectives, a dialogue among all stakeholders should be promoted by exchanging information and knowledge. Traditional knowledge is taken into account in biosphere reserves through scientific research and education for sustainable development.

The importance of bridging scientific and traditional knowledge for sustainable development has been highlighted by several authors (Rozzi et al. 2006, 2012; Berkes 2009; Schultz and Lundholm 2010).

The present case studies have focused on improving biosphere reserve management in southern South America (Cabo de Hornos, Chile), in the Caribbean (Sierra del Rosario and Cuchilla del Toa, Cuba), and in Central America (Bosawas, Nicaragua), by learning and applying local and Indigenous ecological knowledge which empowers different social actors. This article presents empirical cases of networking, interdisciplinary research and education as the three pillars of these experiences.

Intangible Heritage and Local Knowledge

The concept of intangible heritage is a recent one. It is defined by UNESCO in its Convention for the Safeguarding of the Intangible Cultural Heritage (October 17, 2003) as including

> the practices, representations, expressions, knowledge, skills—as well as the instruments, objects, artefacts and cultural spaces associated therewith—that communities, groups and, in some cases, individuals recognize as part of their cultural heritage. This intangible cultural heritage, transmitted from generation to generation, is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity. (Article 2.1)

When applied to local knowledge, the issue of intangible heritage becomes one of the key challenges in the fate of Indigenous people. Ownership of a form of culture, the value given to it or the way in which it can be promoted are all elements that contribute to creating the conditions of its future (Charnay 2005). Moreover the interest in local knowledge could also have scientific, environmental, or economic reasons.

Scientific ecology and local ecological knowledge are potentially complementary. Local knowledge systems provide insights for the qualitative management of resources and ecosystems and for adaptative management (Berkes et al. 2000). However the confrontation between different kinds of knowledge is demanding and implies the need to closely involve the actors concerned in the process. Moreover, the very nature of local knowledge, which is based on specific, diverse, and informal knowledge, makes it difficult to achieve.

Interest in the promotion of local knowledge by the development of tourism has been growing. An original tourist product that is specific to a region is promoted by meeting the expectations of customers made aware of the history of micro-regions, and integrating the tourist dimension into local life. Beyond the conservation of the intangible heritage, the project can create jobs, increase the influx of tourists—with consequence for local trade—contribute to promoting the region, reassert the value of knowledge, and strengthen the local identity.

The following three case studies were selected based on their outstanding research and promotion of local and Indigenous knowledge. The methodology consists of identifying both social and environmental contexts and as well as socio-environmental threats to the local communities and exploring the value of community knowledge for the sustainability of biosphere reserves in future. Local and Indigenous knowledges were promoted for example by the development of ecotourism and biodiversity resources conservation for the benefit of local communities. Activities have been carried out in core and buffer management zones.

Three Lessons from Latin American and Caribbean Biosphere Reserves

Latin America and the Caribbean have 117 biosphere reserves in 21 countries. They cover more than 2.2 million km^2 which include the three zones: core, buffer, and transition. These include both terrestrial and marine ecosystems.

Considering the classification of the Latin American and the Caribbean terrestrial eco-regions by Dinerstein et al. (1995) and Olson et al. (2001), Cabo de Hornos, the most recent of the biosphere reserves presented here, is located in the extreme south of Chile, in the Magellanic sub-Antarctic sub-polar forests, rock, and ice eco-regions. Cuchilla del Toa, and Sierra del Rosario are in the Cuban moist and pine forest eco-regions. And finally Bosawas represents the Central American Atlantic moist forest eco-region (Olson et al. 2001). Regarding their status of conservation, according to Dinerstein et al. (1995) these eco-regions are classified as vulnerable.

The case studies have promoted the conservation of intangible heritage to contribute to the management of natural resources for sustainability of biosphere reserves in the future and to the maintenance of local communities knowledges. Rehabilitation and strengthening of local and Indigenous knowledges have been implemented through the participation of interdisciplinary scientific researchers in each

of three biosphere reserves in close collaboration with community members by establishing both formal procedures and also innovative informal procedures. In all cases this knowledge has been applied in making these sites sustainable while undertaking educational action to disseminate it among other stakeholders, including the local community or other biosphere reserves.

Cabo de Hornos Biosphere Reserve (Chile)

The Cabo de Hornos Biosphere Reserve (CHBR) is located in the subantarctic eco-region of Magallanes. It is one of the twenty-four most pristine eco-regions in the world (Mittermeier et al. 2003). This condition is based on the "pristine" status of the biota in the extreme south of the American continent, where there are still vast areas of un-fragmented temperate forests and a low population density of only 0.23 inhabitants/km^2 (Rozzi et al. 2006).

CHBR represents a milestone for the conservation of both biological and cultural diversity on a global level. Cultural diversity is linked to the Indigenous Yahgan people. The Yahgans, or Yaamana, are the ethnic group located in the most southern part of the planet. Cabo de Hornos represents an ancient archipelago, where a hundred archaeological sites show a pre-Columbian settlement more than 7,000 years old (Rivas et al. 1999). It also occupies a central place in science history by having inspired Charles Darwin's theory on human evolution (Rozzi 1999). Nowadays, the Yahgan population is concentrated in Villa Ukika, a sector of Puerto Williams city (capital of the Chilean Antarctic Province) on Navarino Island, mostly engaged in fishing, handcrafts, construction, and ecotourism.

Local communities are facing various threats in buffer and core zones among which the increasing expectation of becoming a tourism pole. Another risk is the introduction of invasive alien species of flora and fauna through a recent process which implies control measures. Other risks are linked to aquiculture activities, fisheries, and deforestation for timber extraction.

Process of Formation

The singular attributes of, and threats to, these Magellanic sub-Antarctic biological and cultural diversities motivated the creation of the Omora Ethno-botanical Park on land conceded by the National Land Ministry to the University of Magallanes (UMAG) in 1994, for the development of floriculture. In 1999, this Park changed its objectives to developing education, research and long-term bio-cultural conservation. Subsequently, the Omora Park interdisciplinary research team in alliance with authorities and representatives of the local community initiated the preparation of a biosphere reserve proposal—Cabo de Hornos. Several institutions worked together on the proposal: the Government of the Magallanes Region, Municipality of Cabo de Hornos, the Chilean Navy, the National Environmental Commission, the National Land Ministry and National Forest Corporation, together with scientists from the University of Magallanes, other research institutions associated to Omora Park, and local and regional community representatives.

This process, involving hard work on data collection and discussions on the CHBR zonation, lasted for about six years, finally achieving UNESCO designation in June 2005. CHBR is the largest biosphere reserve in the Southern Cone of South America with a surface area of 4,884,274 ha (or 48,843 km^2), including 2,967,036 ha of marine areas and 1,917,238 ha of terrestrial areas (Rozzi et al. 2007).

Bio-cultural Research

In order to achieve bio-cultural conservation and sustainable development of the region, a biosphere reserve management committee was set up in August 2005, chaired by the Government of the Magallanes Region, and comprising the Chilean Antarctic Province Government, the Municipality of Cabo de Hornos and the Chilean Navy. In addition, the role of the Omora Ethno-botanical Park as a scientific centre for the CHBR was ratified. The Omora Park scientific committee participates in the management committee in an advisory capacity, but does not have the right to vote. This scientific centre has been consolidated at national and international levels. At the national level, it participated in the creation of the Chilean Socio-ecological Long Term Study Network in 2008, which is financed by CONICYT (Comisión Nacional de Investigación

Científica y Tecnológica) and the Millennium Scientific Initiative of MIDEPLAN (Ministerio de Planificación Nacional y Política Económica), coordinated by the Institute of Ecology and Biodiversity (IEB). It gathers together researchers from the universities of Magallanes, Concepción the la Sirena, P. Catholic and de Chile (Rozzi et al. 2012). At international level, Omora Park with its UMAG and IEB programs has established the subantarctic Bio-cultural Conservation Programme in collaboration with the University of North Texas (USA). These programs are members of an active network with other centres and Latin American biosphere reserves, as for example with the Charles Darwin Station in the Galapagos Biosphere Reserve.

Long term bird monitoring is associated with ethno-ornithological research that registers indigenous Yahgan and Mapuche knowledge about birds, as well as migratory patterns and bird ecology (Rozzi et al. 2010). Other research programs include marine biodiversity, in particular seaweed, the diversity of non-vascular flora and invertebrates, as an ecosystem service, alien invasive species and comparative environmental ethics (Schüttler et al. 2009; Schüttler et al. 2011).

Management of the Cabo de Hornos Biosphere Reserve

Actions have been focused on sustainable development and education.

Sustainable tourism initiatives such as "meeting face to face with birds," "Ethic birding," the "route of Darwin in Cabo de Hornos," or "ecotourism with hand lens" are emphasized. A new aspect of tourism has been valued, namely bio-cultural Yahgan ecotourism.

Determination has been carried out on the negative impact of alien invasive species of mammals such as mink (*neovison vison*), beaver (*castor canadensis*), pigs, and dogs on the avifauna, pristine forests, archaeological sites and guanaco populations (Anderson et al. 2006, Schüttler et al. 2009). A program to control these alien invasive species has been prepared in collaboration with the Livestock and Agriculture Service, the Regional Government and the Omora Ethno-botanic Park

Education: Omora Ethno-botanic Park represents an outdoor class to get to know and value subantarctic biological and cultural diversity aimed at several actors in schools, kindergartens, public services, members of the Yahgan Community, Navy personnel, and other residents, such as tourism operators and visitors. It covers names of flora and fauna in different languages, including Yahgan. The Omora Ethno-botanic Park sub-Antarctic Bio-cultural Conservation Programme established permanent scientific workshops at Puerto Williams high school. The first science education program for preschool children has been created by CONICYT under the slogan: "Small Explorers of Cabo de Hornos Miniature Forests." Education on Yahgan ecological knowledge is undertaken by generating a child's dictionary, workshops on the Yahgan language, a new educational program about the Yahgan language and culture (Fig. 1), and the establishment of guest houses and other infrastructure with members of the Yahgan Indigenous communities of Bahía Mejillones.

Sierra del Rosario and Cuchillas del Toa Biosphere Reserves (Cuba)

Sierra del Rosario Biosphere Reserve (SRBR) is located in an area characterized by low-lying Jurassic and the Cretacic mountains and was designated as a biosphere reserve in 1984. This chain of mountains is the central watershed, not only of the biosphere reserve itself, but also of Cuba. Sierra del Rosario contains several plant formations such as evergreen forests, semi-deciduous forests, pine forests, dry sclerophyllous low forests, a "mogotes" complex (remnants of eroded sedimentary limestone layers) and secondary vegetation. The flora in the reserve includes a total of 889 plant organisms, of which 608 are higher plants (trees, bushes, and herbaceous plants) and 281 lower plants (fungus, mosses, and lichens). Vertebrate fauna in the SRBR is characterized as in the rest of the country by a paucity of mammals and a greater abundance of birds, reptiles, amphibians, and invertebrates.

Economic activities include ecotourism, forestry activities (reforestation), cattle raising, agriculture and beekeeping (UNESCO 2011). The most outstanding tourism attraction is the Moka Hotel in the "Las Terrazas" community and the Soroa orchid garden (Fig. 2). This is a unique hotel because it is totally integrated with the surrounding environment and local population

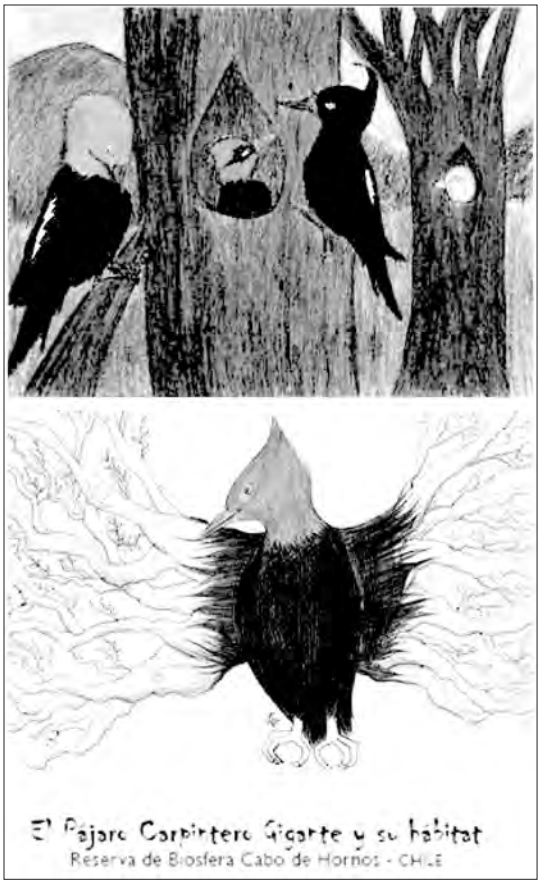

Fig. 1
The largest Woodpecker, Yahgan a most charismatic bird. Drawn by children. Courtesy of Ricardo Rossi.

Fig 2
Moka Hotel in the "Las Terrazas." Photo courtesy of the Cuban MAB National Committee

living and working with tourism related activities.

Main threats to local communities are climate change and natural disasters. In Cuba, hurricanes are the most frequent natural disaster. Other causes of disasters are intense rains, storms, and pluvial inundations associated with hurricanes, strong winds and coastal flooding, and drought.

Process of Formation

In 1968 the socioeconomic development plan of Sierra del Rosario was implemented, which included the reforestation of 5,000 hectares of an area degraded by several activities, such as the coffee industry at the beginning of the 19th century. The reforestation project restored the natural landscape based on experimental research.

In 1974 research work was started on the evergreen forests of Sierra del Rosario, their structure, operation, composition, and restoration. The Ecological Research Centre was created, located within the Sierra del Rosario Biosphere Reserve itself, to develop research projects. This socioeconomic development plan also included the construction of Las Terrazas Community, which gathered some 120 families which were scattered across the region (Herrera and García 1995).

Restoration of the forests by means of reforestation in an experimental system of constant platform terraces made it possible to prepare the biosphere reserve proposal, approved by UNESCO in 1984 (Herrera 2001).

The Ecology and Systemic Institute (1988) published a monograph on tropical evergreen forests, which facilitated the adoption of decisions for its preservation, forestry exploitation, and restoration. Climatic data have contributed to the monitoring of global climate change

In 1991, with the creation of Las Terrazas Community Tourist Complex, the basis for the sustainable development of the community was set. Thirteen years later, from 2004 onward, the project became self-managed and contributes resources to the development of the area (Araya and Clüsener-Godt 2007).

Cuchillas del Toa Biosphere Reserve (CTBR) founded in 1987, harbours the highest levels of biodiversity and endemism in the Antilles. It is considered to be a main evolutionary centre, a biogeographical bridge and refuge for Caribbean and American biota. It is one of the most extensive and best conserved remnant mountain ecosystems of the Antilles region, including 15 hydrographical basins, 32 sub-basins and more than 300 third-order well-protected water courses. It is a rare sample of the development of Karst formations and systems on non-carbonated

lithology. Cuchillas del Toa is a conjunction of mountains with well-conserved broad-leafed woodlands and pine forests in a rainy environment (UNESCO 2011) (Fig. 3). Forestry and agro-forestry are the main economic activities, compatible with conservation goals and ecosystem integrity. Other economic activities include coffee, coconut, and cacao cultivation, agriculture and cattle raising, as well as nickel, chrome, iron, and cobalt mining.

Conservation and research of agro-biodiversity

A characteristic of traditional agriculture systems in Latin America and the Caribbean is their high biodiversity. They represent experience accumulated by peasants interacting with their surroundings, without access to external supplies, capital or scientific knowledge (Altieri 1999).

Cuba is a refuge for native agricultural biodiversity crucial to humans in tropical island environments. Much of this agricultural biodiversity only remains within and around Cuba's six MAB Biosphere Reserves. These areas contain genetic resources of global significance of legumes, neo-tropical fruits, roots and tubers, and spices, including both traditional varieties and wild relatives of crops, together with a rich diversity of associated organisms essential for sustainable agriculture. This bio-cultural heritage in the Cuban biosphere reserves is attributable in part to the complex interactions between the productive activities of local communities and the conservation of agricultural varieties. The high diversity of cultivation has conserved soils to maintain high values of organic matter and a satisfactory water-air relationship. The distribution of crops and their rotation make the rational use of natural resources possible. Environmental education is the other reason for the conservation of agricultural varieties. Diverse wild, semi-wild and domesticated plant species found within and around the protected areas not only have tolerated human activities but have also relied on certain agricultural practices, and changing environmental conditions.

The communities living in the biosphere reserves depend on agriculture. They have managed wild crops for generations. Many useful practices promote synergy between wild and cultivated agricultural biodiversity, however they have been ignored and under-valued (Latournerie et al. 2009).

Fig. 3
Cuchilla del Toa Biosphere Reserve. Photo courtesy of the Cuban MAB Committee.

Sociological and cultural studies have been conducted on the lifestyles of inhabitants, their aspirations and difficulties.

Some of the main results achieved by the National Centre for Protected Areas (CNAP) and the Institute of Fundamental Investigation in Tropical Agriculture (INIFAT) concerning agro-biodiversity in the biosphere reserves presented are the following:

> Baseline inventories of a total of 322 species cultivated by local communities, in the form of traditional varieties used as food, fodder, spices, ornaments, insecticides, craft-making, tools, and for spiritual purposes in SRBR.
>
> Research on the genetic diversity of those species.
>
> Maintenance of home gardens or conucos as well as shady coffee and cacao groves by the communities.
>
> Assistance of rural communities in the buffer and transition zones in growing 258 cultivated species in RBCT.

Wild and cultivated seeds are identified to be used by local communities. Once identified, these materials are tested and improved to be integrated into the Cuban agriculture program and disseminated to the farmers' *conucos* by INIFAT. Such mechanisms include the adoption of indigenous crops and crop variety manage-

ment practices and the maintenance of a local seed system (seed stores and supply) supported by community biodiversity registers and agricultural biodiversity fairs. In addition, impact indicators of agricultural biodiversity management practices that maintain ecosystem service integrity, such as soil biodiversity, soil runoff, water quality, are also being used to design sustainable agricultural biodiversity management practices within and around biosphere reserves.

Management of Sierra del Rosario and Cuchillas del Toa

Traditional agricultural biodiversity knowledge is recorded, and this knowledge integrated by the National Centre for Protected Areas (CNAP) into the management plans of Cuban biosphere reserves. In addition they include education and research activities in management plans specifically related to traditional agricultural knowledge.

Sustainable development: One of the methods tested is to acknowledge current sustainable agricultural practices in the Sierra del Rosario and the Cuchillas del Toa biosphere reserves through the development of licensing schemes for households and communities who agree to practice sustainable agricultural methods. These schemes establish a number of sustainable agricultural practices, which are consistent with the conservation and the integrity of the reserves' ecosystem services.

Education: The seeds fairs offer the possibility of strengthening the informal seed system in these regions and facilitating the exchange of seeds among farmers, increasing their capacities for agro-biodiversity management. The fairs were developed with municipal participation during 2005 and 2006 with farmers in or around Sierra del Rosario, in Pinar del Río, and Cuchillas del Toa Reserve, in Guantánamo. Seed fairs were particularly efficient in the recovery of rare species thought to be extinct by farmers, and in reintroducing them to farms where there was still a demand for such seeds. These fairs represent a valuable and inexpensive means for the informal exchange of seeds (Shagarodsky et al. 2009).

The external recognition of the diversity existing in the farms, as well as the news on the official registry of farmers' cultivars, made farmers aware of their contribution, and this has increased their self-esteem.

In response to farmers' requirements training included issues such as soil management, pest and crop diseases, as well as post-harvest management. Part of the training was focused on women, especially to promote their silent leading role in the informal seed systems and to strengthen their knowledge on seed selection, cleaning and storage, as well as their knowledge on the nutritional values of seeds.

Bosawas Biosphere Reserve (Nicaragua)

Bosawas Biosphere Reserve is the ancestral birthplace of the Mayagnas and Miskitus Indigenous peoples. It includes seven Indigenous territories: Mayangna Sauni Bas, Mayangna Sauni As, Mayangna Sauni Arungka, Lilamni Tasbaika Kum, Kipla Sait Tasbaika kum which are located in the North Atlantic Autonomous Region (RAAN, its Spanish acronym) and Mayangna Sauni Bu and Miskito Indiam Tasbaika Kum in the Department of Jinotega, which represent the integrity of its historical, cultural, and natural heritage.

The main threats are deforestation and land occupation by the *colonos* which is putting pressure on Indigenous peoples living in the buffer and core zones of Bosawas.

Process of formation

Bosawas was designated a reserve in 1979. The process was interrupted and taken up again in 1991, with decree 44-91 which created the Bosawas National Reserve. The Bosawas Biosphere Reserve is intended to safeguard not only Nicaragua's tropical forests, but also the resources and cultural heritage of the Indigenous groups (Stocks 1998). The surface of the Bosawas Biosphere Reserve has increased greatly, and now includes other protected areas, spanning the seven Indigenous territories.

According to the Bosawas biosphere reserve management plan (2003) and unlike the customary structure of the biosphere reserves, in this area there is an intangible core area, uninhabited, and a tangible area which holds Indigenous territories and some *mestizo* populations. The buffer zone comprises six municipalities excepting the core zone.

The biological diversity of this region makes it a part of the main natural wealth of the country, with 370 major flora species, including trees and bushes, 215 bird species, 85 species of mammals and 15 of poisonous snakes.

The Bosawas Biosphere Reserve (BBR) is one of the eleven priority areas for biodiversity preservation in Central America, and plays a key role in regulating climate regionally and globally. It was the first Nicaraguan Biosphere Reserve to be acknowledged and incorporated under the Man and the Biosphere Program (MAB), into UNESCO's World Network of Biosphere Reserves on October 28, 1998. Within its 812,956 hectares of core zones it holds the last strongholds of tropical rain forest, as well as of humid tropical forest and cloud forest. Such formations include highly heterogeneous botanical and faunal compositions which are a genetic reservoir of rare and endangered species in other parts of the Central American tropics.

Additionally, the BBR has a buffer area of more than one million hectares, so that core and buffer zones jointly represent 15.25 per cent of the national territory.

Botanical diversity in the Bosawas Biosphere Reserve is very high. Preliminary data estimated that there are thousands of tree and vascular species. Likewise, although entomo-fauna has not yet been explored, a rough calculation shows between 100-200,000 species of insects. According to Holdridge's life zone classification (Holdridge 1967), the area of the BBR includes three life zones: tropical moist forest, tropical pre-montane wet forest, and low montane wet forest. These three life zones are very important eco-regions in terms of the biodiversity they host and, at the same time, are considered to be vulnerable regarding their final state of conservation. The main economic activities in the BBR are coffee-growing and cacao-growing, agro-forest-pastoral systems and industrial and artisanal mining.

Research on Mayangna knowledge

UNESCO LINKS (local and Indigenous knowledge systems) developed a project to record indigenous Mayangna nature knowledge. This responds to the interest of the Mayangna people to first record their knowledge on fish and turtles, because they represent a source of food and the way of life of the Mayangna. The project carried out more than thirty community meetings and scored individual and group interviews over a period of several years to ensure a thorough recording of Indigenous knowledge and active community engagement within the process. The Mayangna communities collecting information about thirty fish and six turtle species described their behaviour, habitat, reproduction, and migration patterns. The book published in both the Mayangna and Spanish languages contributes to the transmission of Indigenous biological knowledge, traditional fishing techniques, and environmental changes in relation to the behaviour of species (Gros and Frihz 2010). Moreover, the communities involved in the project will benefit and be strengthened with the exchange of information and knowledge process.

Traditional and scientific research

Several themes are approached in scientific research on knowledge of fish and turtles; the Indigenous vision about nature, and in particular about aquatic animals, fishing techniques and recommendations to fisheries management for future generations. The biology of species is also considered, as well as the use of these species by communities and their role in Indigenous culture. Each species, its morphology, ecological characteristics, habitat, feeding habits, predators, and reproduction have been recorded. The abundance of species has been determined in order to identify endangered species, as well as species having a high rate of reproduction to compensate for fishing pressure. Indigenous knowledge about fish and turtles in Bosawas biosphere reserve was sometimes contradictory with scientific research, as for example when fish migration and their habitats are described. The project offered mutual learning opportunities.

Management of the Bosawas Biosphere Reserve

Sustainable development: Since May 2007, the Nicaraguan government has recognized four indigenous Mayangna and three Miskito community territories including 32,000 inhabitants. Mayangna communities live in high lands and co-manage this biosphere reserve together with the

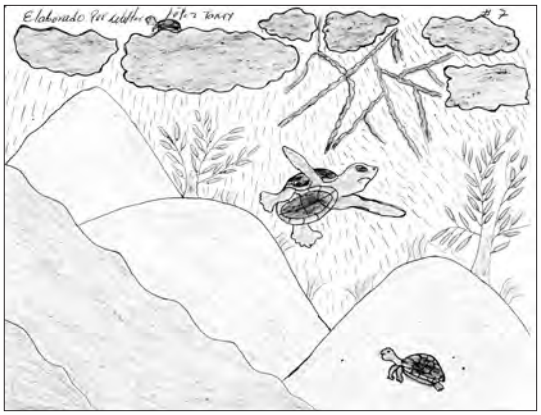

Fig. 4
Drawn by Orlando Bruno on "pecho quebracho" tortue (Kinosternon leucostomum). Courtesy of UNESCO.

Municipalities and SETAB (Technical Secretary of Bosawas) (Araya and Clüsener-God 2007). They ensure the conservation of biological and cultural diversity. However a key factor to reduce the increasing threats is the recognition of the value of the community property of Indigenous territories and of its multiple use strategy as an instrument that facilitates the integration between conservation and development. Data on soil use analysis reveal that the multiple use strategy has resulted in a very low impact in terms of deforestation by Indigenous communities (Stocks et al. 2007).

In addition, since late 2009, local initiatives for sustainable production are being implemented directly with the communities, intended to generate resources by the Mayangnas and Miskitus Indigenous communities. The objective is to improve the living standards of families, based on production through the sustainable use of natural resources, founded on territorial planning and ecological regulations. These activities comprise direct planting of agro-forestry systems with cultivation of species traditionally consumed in the area, including agro-forestry, reforestation, and conservation of natural resources.

The experience shows that the relationship between the productive activities which are more accepted and practised in the area is closely linked to the conservation of water sources, which is a key to raise awareness on the development of activities favouring the balance between production and natural resources conservation.

Education: The book *Conocimientos del pueblo Mayangna sobre la convivencia del hombre y la naturaleza: peces y tortugas*. (Mayangna knowledge about the interdependence of humans and nature) (Gros and Frihz 2010) on knowledge and practices about the use of natural resources.

The book was distributed in one pilot primary school in the Mayangna communities, to be used as reference material for teachers and students. The content is included in the schools natural science curricula. Adults will have access to the information in libraries and associations where it is easily available. Another form of dissemination is organized through communal and religious assemblies. With reference to the communities in the buffer zones which are larger than in Indigenous territories, access to the information is planned through multimedia and radio.

Conclusion

The planet is currently being seriously impacted by different drivers of change such as changes in atmospheric carbon dioxide, climate, vegetation, and land use (Sala et al. 2000). Protected areas are not excluded from those impacts and might function as arenas for testing sustainability approaches and transmitting learning experiences. Worldwide, there are many biosphere reserves that are currently developing a combination of biodiversity conservation, socioeconomic development and education, training, research, and monitoring. What remains a challenge is finding cases where different stakeholders interact, exchanging knowledge and experience and learning for sustainable development (Ishwaran et al. 2008). The focus should be on learning what improves biosphere reserve management through changes in management practices, institutions, and individuals (Shultz and Lundholm 2010).

The case studies presented here represented different approaches to achieve social, economic, and environmental sustainability. Despite their differences, the four biosphere reserves shared a common aspect: the exchange between traditional ecological knowledge and scientific knowledge and its application to resources management approaches. Furthermore these three case studies showed their potential for the conservation of biodiversity resources by contributing to the reduction of threats affecting biosphere reserves and protected areas.

On a global basis, remaining cultural diversity is strongly linked to remaining biodiversity. It is recognized that Indigenous people have

maintained, and in some cases even enhanced, local biodiversity (Gagdil et al. 1993). Links between biological and cultural diversity have also been illustrated in the Global 200 program that proposes areas of priority for biodiversity conservation based on eco-regions (Toledo 2001). A preliminary analysis revealed the presence of Indigenous people in 136 of the 233 terrestrial, freshwater, and marine eco-regions identified by Global 200, a WWF program (World Wide Fund for Nature) which classified the areas for conservation into eco-regions. Land tenure and stewardship systems, combined with knowledge and know-how, play a very important role in conserving natural ecosystems. However, traditional ecological knowledge continues to decline although there are an increasing number of co-management systems of protected areas and a number of sustainable use areas. Thus, for future biosphere reserve strategies and policies for biodiversity conservation it is crucial to retrieve, preserve, and use Indigenous and local knowledge. Our case studies have shown different ways of protecting, rehabilitating, and enhancing local and traditional knowledge while strengthening it, aimed at vulnerable populations.

In this paper we have shared some important lessons from three case studies from Chile, Cuba, and Nicaragua.

The implementation of a young biosphere reserve such as Cabo de Hornos implies, in general, huge challenges: it is a very remote area that entails great logistic and administrative difficulties. At the same time, the region faces increasing development pressure, as for example salmon culture and massive tourism threatening cultural and biological diversity. The tourist trade is attracted by its pristine characteristics. To maintain and reinforce links between cultural and biological diversity, it is critical that the government should take on a more proactive role, defining and implementing a management plan, and ratifying the CHBR management committee defined in 2005, which includes representatives from the Yahgan indigenous community.

In the case of Sierra del Rosario and Cuchillas del Toa biosphere reserves, management and retention of their agro-biodiversity is a special challenge. These cases showed the main limiting factors as being the supply of seeds to farmers considering that there is a lack of information about the proprieties of seeds and sources of exchangeable seeds as well as on guaranteed germination and on yield associated to seeds. Moreover, these areas are vulnerable to climate disasters such as hurricanes which could affect agro-biodiversity. Agro-biodiversity practices would allow conservation of species of economic importance in the event of adverse conditions.

Mayangna knowledge, practices and beliefs about fish and turtles ensure sustainable natural resource use from the Bosawas biosphere reserve experience. They are regulated, based on management norms and on their knowledge and beliefs about the interdependence of humans and nature. Indigenous people are experiencing rapid social, cultural, and environmental change. While this change may offer new opportunities, it may also put at risk their rich cultural heritage by disrupting the transmission processes of Indigenous knowledge. Regarding actions to secure land and resources, the occupation that threatens Indigenous lands should be reduced (Stocks 2003; Stocks et al. 2007). Moreover, a policy to combat deforestation should be implemented to to contribute to maintain biological and cultural diversities in core and buffer zones.

As a conclusion, biosphere reserves should promote exchange, learning, and transmission processes of local and Indigenous community knowledge and contributing to safeguard the intangible heritage. In addition, policies should be implemented to directly benefit traditional and Indigenous communities by promoting their participation in biosphere reserve management decisions and benefit-sharing mechanisms foreseen in UN conventions.

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