ECOTOURISM WITH A HAND-LENS TO APPRECIATE THE BRYOFLORA: AN INVITATION FROM THE SOUTH

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Today a vast diversity of living beings and human values, traditions, and perspectives are invisible as they are outside the narrow worldview governing global society. The prevalence of a utilitarian, economic worldview -- the lens through which we view the world -- has resulted in a narrow valuation of biodiversity. Furthermore, there is also a bias in the intensity of research that is concentrated in the Northern Hemisphere and in particular components of biodiversity (Rozzi et al. 2008a, 2012a). As an example, until the end of the 20th century, global standard biodiversity assessments based on vascular plants resulted in the perception of poor floristic diversity of southwestern South America (Fig. 1). Our long-term ecological and botanical studies at the Omora Ethnobotanical Park (Fig. 1) in Puerto Williams, Chile, however, disclosed the exceptional floristic uniqueness in the archipelagoes of Cape Horn at the southern end of the Americas: non-vascular plants had a greater diversity than vascular plant species, a pattern of floristic diversity that contrasted with all Chilean ecosystems at lower latitudes (Fig. 2). Moreover, the Cape Horn archipelagic region hosts >5% of the world's species of non-vascular plants. These discoveries stimulated the research team at Omora Park to "change lenses" to better assess biodiversity. Focusing on both vascular and non-vascular plants –rather than solely on vascular plants as done previously (crf. Myers et al. 2000) – and on high latitude ecosystems in the Southern Hemisphere is essential to overcome a historical bias toward vertebrates and vascular plants in the northern hemisphere underpins how global patterns of biodiversity in terrestrial ecosystems have been assessed (Rozzi et al. 2008a). This change has made visible an idiosyncratic biodiversity in Cape Horn, and more generally in high latitude ecoregions where non-vascular plants typically contribute significantly to species richness. In turn, making visible the species richness of non-vascular plants provided a central argument that lead to the creation the UNESCO Cape Horn Biosphere Reserve in 2005 (Rozzi et al. 2006).

Ecotourism with a Hand-Lens in the UNESCO Cape Horn Biosphere Reserve

For the first time, a protected area had been designated based on the diversity of mosses and lichens, organisms which had rarely been perceived and valued in the international conservation community. Shifting lenses away from a solely economic worldview was a key step in the conceptual pathway that lead to this tangible conservation victory. Integrating ethical, aesthetic, and ecological lenses alongside the economic lens required the development of a novel methodological approach: the Field Environmental Philosophy (FEP) methodology. The FEP four-step cycle provides a framework that guides the integration of research into applied conservation outcomes and involves: i) interdisciplinary ecological and philosophical research, ii) composition of metaphors and their communication to the general public through simple narratives, iii) design of guided field experiences with an ecological and ethical orientation, and iv) implementation of *in situ* conservation areas. The discovery of non-vascular plant diversity in the sub-Antarctic

Magellanic ecoregion and the subsequent designation of the Cape Horn Biosphere Reserve illustrates the successful implementation of the FEP four step methodology (Fig. 3).

As part of these innovative efforts, researchers at Omora Park faced the challenge of developing new ways to communicate the aesthetic and ecological significance of mosses and lichens to diverse audiences, and ultimately of creating new ways of interacting with the regional flora. The "miniature forests of Cape Horn" metaphor was composed to communicate that the little species of mosses and lichens support diverse tiny ecosystems (Goffinet et al. 2012). The field activity *ecotourism with a hand-lens* (EHL) was invented to help citizens and decision makers to discover the beauty, diversity and ecological importance of the Magellanic ecoregion's extraordinary flora (Fig. 4). Direct encounters with mosses and lichens in the physical space of the "miniature forests of Cape Horn" focused with the help of an EHL guide summons ethical, aesthetic, and biocultural values in order to broaden the relationship of global society with nature beyond the singularity of the economic lens and the associated value system (Rozzi et al. 2012b).

EHL helps global citizens to experientially understand the modern scientific concept of the *unity of life* and the theory of biological evolution, and their ethical implications (crf. Rozzi 1999). According to concept of the *unity of life* first formally stated in the 19th century as the cell theory, all known living beings are made up of one or more cells, all cells have the same basic chemical composition, heredity information [DNA] is passed on from cell to cell, energy flows occur via cellular respiration within cells (Tavassoli 1980). According to the theory of biological evolution, all living beings are descended from a single common ancestor (Mazzarello 1999). At Omora Park, field observations of mosses, lichens, birds, and other organisms, their life habits and habitats, are complemented by readings of Western philosophers, such as Aristotle (who claimed that all living beings have a soul, the vegetative soul that alludes to the capacity of breathing, growing, and reproducing) or Saint Francis (who referred to plants and animals in terms of sisters and brothers), Native American ecological knowledge and other forms of traditional ecological knowledge. The combination of field observations and readings, is portrayed with a biocultural metaphoric invitation to the visitors to read the "books of nature" and the "books of culture." This biocultural experience combining the "reading" of the biophysical and cultural dimensions of the observation, as well as conservation of the bryoflora and biodiversity helps the visitors to better grasp the deeper meaning of the scientific and cultural worldviews that propose an evolutionary and ecological unity of life (Aguirre 2014). Based on this experiential and intellectual understanding, visitors gain awareness about the vital pulse that is common to mosses, humans, and all living beings. Consistent with the contemporary scientific knowledge, as well as other cultural forms of knowledge, the biocultural ethic developed at Omora Park affirm that rather than as *natural resources* (or even human resources) mosses, humans and other living beings should be considered in a more integral way as *co-inhabitants* (Rozzi 2013).

The biocultural ethic conceptual framework affirms the value of the interrelationships between the life habits of the co-inhabitants and the habitats where they take place. With this conceptual framework, ecotourism with a hand-lens is an activity that is practiced in different types of habitats that visitors can find at Omora Park, such as the characteristic sub-Antarctic peatlands, high Andean zones, beaches, and forests. In the peatlands of Cape Horn there is a great variety of mosses, including the endemic *Tetraplodon fuegianus*, which has long sporophytes with conspicuous capsules and spores (Fig. 5). On the rocky beaches of the Cape Horn Biosphere Reserve, several distinct bands of colors composed of a variety of conspicuous communities of crustose and fruticose lichens can be observed (Fig. 6). Among these *Ramalina terebrata* has attracted attention because it contains several antibacterial compounds effective even against

Staphylococcus aureus (Paudel et al. 2010). Above the tree-line, the high-Andean habitats are characterized by low temperatures and strong winds, and a highly diverse community of bryophytes and lichens grow amid the rocks and stony ground (Méndez et al. 2013). One of the most abundant types of high-Andean lichens belongs to the genus *Usnea*, which has distinctive dark colors that protect them against high UV radiation (Fig. 7). The sub-Antarctic forests provide a more protected habitat for a hundred of species of endemic mosses, among them *Tayloria mirabilis*, which is another dung moss (Fig. 8). *T. mirabilis* develops bright white capsules to attract flies that are potential vectors for the dispersal of the spores to fresh piles of feces or carrion, which are appropriate for the germination of the spores and establishment of the moss since "dung" is rich in nitrogen, a limiting nutrient in the sub-Antarctic forests (Jofre et al. 2011).

Naming bryophytes and lichens

In addition to biological research, graduate students and researchers at Omora Park have also conducted philosophical and ethnographic research to address critical linguistic gaps. Researchers are developing ways to address linguistic challenges associated with communication and development of educational and cultural activities that feature under-perceived and typically un-named biodiversity. A lack of common names for most moss and lichen species has necessitated the reliance on well-developed western scientific names.

Contemporary scientific names are based on the Aristotelian logical system of hierarchical taxonomy organized in classes, orders, families, genera, and species, which was adopted and adapted by Carl Linnaeus in the 18th century. In this system, each name includes a genus that is a noun (hence it is capitalized) that indicates an essential attribute of the organism, and a species name that is an adjective (hence it is written in lowercase) that indicates an accidental attribute of the organism. For example, in the case of *Tetraplodon fuegianus* the name indicates the essential attribute of having the arrangement of the peristome's teeth joined in four when young (Gr. *Tetraplo* = fourfold; *odous* = tooth), and the accidental attribute of having discovered the species for the first time in southwestern Tierra del Fuego (Fig. 5).

Scientific names, despite the clarity of its conventions, are often cumbersome for people that do not identify with scientific culture or are unfamiliar with the conventions of binomial nomenclature. Furthermore, scientific names are not culturally relevant to the full range of people that interact with the miniature forests. Just as the singularity of the economic lens has resulted in cultural and ethical blind spots, the presence of names from a singular cultural tradition results in biocultural blind spots. To overcome this limitation, the FEP four step cycle develops novel ways to highlight the connections between diverse humans and non-humans co-inhabitants in the miniature forests through linguistic, cultural, etymological, ethno-ecological, and historical research. Research is experientially shared with visitors through naming activities that engage them in the discovery and invention of bryophyte and lichen names, as well as drawing and group actions that enhancing the understanding of the origin and implications of naming biodiversity. Names are symbolic representations of the biophysical mosses and lichens. They reveal essential aspects of the relationship between the plant that is named and culture that names it; hence, it conveys an essential biocultural relationship between the biological and the cultural dimensions. Just as the number of moss species present in the miniature forest is interpreted as species richness, the number of different names associated with different cultures represents a biocultural richness. The biocultural aspect of diversity in the miniature forest is exemplified by the various names given to the lichen *Protousnea magellanica* (Fig. 9a).

The names given to *Protousnea magellanica*, the "Old Man's Beard" lichen, by five cultural groups that cohabit in the temperate forests of South America illustrate the concept of biocultural interrelationships. For the Yahgan culture that inhabit Cape Horn, the Old Man's Beard is a type of *chirlej* (the common name for mosses and lichens) that hangs from the trees and was smoked (Fig. 9b). The Mapuche culture, inhabiting southern central Chile, gives the common name of *poñpoñ* or *kalcha* to mosses and lichens. To give names to the plants, the Mapuche pay attention to the habitat and substrate where they grow. For this reason, *Poñpoñmamüll* or *kalchaliwen* is the name for the lichens and mosses that grow on wood (*mamüll*) or trunks (*aliwen*). The Mapudungun name *kalcha-aliwen* exhibits remarkable convergences with the names in Spanish "barbas de viejo" and in English "Old Man's Beard," "Beard Lichen," or "Treemoss." The European and the Mapuche names allude to the similarities between the hairs of humans and the hyphae of lichens, at the same time that they refer to the interrelationships between the life habits of the lichen and the habitat provided by the tree.

Regarding a vital interrelationship between plants and humans, the Mapuche calls medicinal plants *lawen*, and the lichens with medicinal properties are called *kalchalawen*. For the Mapuche, *kalcha-aliwen*, the Old Man's Beard, is a *kalchalawen* that is prepared as a tea for purifying the blood, to cure ulcers and stop diarrhea. This Native American naming and traditional ecological knowledge converges with the origin of the scientific knowledge about the lichens of the genus *Usnea*. During the Middle Age, the doctor Ebubekir Muhammed bin Zekeriya Razi studied the healing properties of mosses and lichens in his Islamic region, and coined the Latin name of the genus *Usnea* based on the Arabic name for the Old Man's Beard: *ushnah*. More broadly, the Mapuche and Islamic knowledge about the Old Man's Beard present notable similarities. In these two cultures, as well as in China, Europe and North America, this lichen has been utilized in traditional medicine for over a thousand years (Cabrera 1996). In the 19th century, modern science discovered that it possess a strong antibiotic that is effective in the treatment of several bacterial diseases, and it also exhibits antiviral, antiprotozoal, antimitotic, anti-inflammatory and analgesic activity: usnic acid. Today, usnic acid is included as an ingredient in medicines, toothpastes, hair shampoos and many other products that express the lichen-human biocultural interrelationships in modern society.

The example of the names of *Protousnea magellanica* illustrates how bioculturally focused examination of names and the act of naming discloses a "symbolic-linguistic forest" of names and concepts that parallels and interacts with the biophysical diversity of the miniature forests. The FEP four step methodology has provided a structured way to interrelate the "biophysical and the symbolic-linguistic or cultural forests," and with this biocultural understanding to conduct effective actions for developing formal and non-formal education programs at Omora Park that contribute to the conservation of both, biological and cultural diversity. A great strength in the FEP approach is its generality and flexibility, which makes it applicable to other regions in the world. For example, as you may walk through the forests of Estonia, stopping perhaps to admire the shrubby, richly branched thallus of the Powered or Lapland beard lichen, *Usnea lapponica*, we invite you to join us in the playful exploration of the biocultural significance of this species' scientific name. As mentioned above, the Latin name of the genus *Usnea* has been traced back to the Arabic word *ushnah*. Like in the case of *Tetraplodon fueginus*, the species name *lapponica* refers to the region where the species was first collected and scientifically described (Bjerke et al. 2006). Thus in the name of *Usnea lapponica* in the forests of Estonia, we encounter linguistic roots of Arabic, Latin, and Northern European cultures. The cultural dimensions of the Lapland beard lichen are not limited to language, but they also include traditional medicinal practices. For

example, the hairlike structure of the lichen offers an effective application as a poultice, and usnic acid extracted has been used as a potent antibiotic and antifungal agent for at least 1600 years (Shrestha et al. 2014). From an ecological cultural perspective, it is important to note that Usnea lichens are sensitive to air pollution, especially to sulfur dioxide and enhanced atmospheric nitrogen (N) deposition (McMurray et al. 2013). Therefore, for the conservation of subpolar lichens and the bryoflora, the protection of habitats is as important in Estonia and other subarctic regions of the Northern Hemisphere as it is in Cape Horn and other the sub-Antarctic regions of the Southern Hemisphere.

Two learned lessons and an invitation from the southern end of the world

Our experience demonstrates that inconspicuous taxonomic groups, such as bryophytes, can play important roles in promoting conservation when their ecological and aesthetic values are understood by the general public and policy makers. The high diversity of sub-Antarctic Magellanic non-vascular flora was critical in making the case for the establishment of the Cape Horn Biosphere Reserve in June 2005. Bryophytes, although very small organisms in comparison to charismatic megafauna and large tree species, have the potential for becoming emblematic flora at other subpolar latitudes.

Our experience also demonstrates the crucial role of international partnerships to conduct effective long-term ecological research and education programs. Creating a program focused on non-vascular plant diversity in the Cape Horn archipelagic region without international collaboration would have been difficult because of the lack of trained Chilean bryologists and taxonomists. In turn, collaboration among international and Chilean institutions and scientists with different cultural experiences and fields of expertise was essential for promptly translating novel scientific knowledge into regionally and globally significant conservation actions, leading to the creation of the world's southernmost biosphere reserve. This process reached a landmark point by hosting the International Association of Bryologists Conference at Omora Park in January 2015. This conference was inaugurated by Chilean President Michel Bachelet (Fig. 10), who announced the creation of the new Sub-Antarctic Cape Horn Center that will be inaugurated in Puerto Williams in 2017. The center will house world class programs in ecological education, sustainable tourism and transdisciplinary research. It will also contain an exhibition space, an auditorium, research and laboratory facilities, and apartments for visiting researchers. We invite the international community of bryologists to be part of the research in this unique natural laboratory in Cape Horn. This collaborative initiative can help to overcome historical taxonomic and geographical biases in botanical research, and to better understand and conserve the richness and value of remote high-latitude ecosystems, and of the (until now) under-perceived and under-valued bryoflora.

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