



SUPPLEMENTARY MATERIAL

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Creating a new cadre of academics capable of integrating socio-ecological approach to conservation biology

Formando una nueva generación de investigadores capaces de integrar los aspectos socio-ecológicos en conservación biológica

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ABSTRACT

As education shapes the thinking of the next generation of researchers, its conceptual framework, analytical tools and the way in which these interact with their natural surroundings, will significantly impact scientific studies, policies and decision making. The objective of this article is to analyze how graduate programs in Chile related to ecology and natural resource management are integrating socio-ecological aspects in their courses of conservation biology. Additionally, we present our perspectives about the processes, benefits and challenges that arise with participation in programs with interdisciplinary emphases. In Chile, we reviewed 22 graduate programs (nine doctoral and thirteen master's) related to themes of ecology and natural resource management and certified by the National Accreditation Commission as of October 2008. Of them, 64 % had a course in Conservation Biology. In spite of some integration of socio-economic aspects in the contents of these courses, the educational perspective of these continues to be within a utilitarian paradigm, which contrasts from broader approaches encompassed within environmental philosophy. We propose that it is necessary to change the teaching paradigm of conservation biology in Chile, such that it addresses social and ecological aspects that transcend utilitarian and instrumental values, incorporating the human being within ecosystems and the non-equilibrium ecosystem model. To integrate the socio-ecological perspective in conservation courses, we propose the inclusion of four educational components: (a) biocultural approach, (b) interdisciplinarity, (c) multi-directional communication and participation, and (d) field experiences and direct encounters with nature and the local communities.

Key words: biocultural, Chile, conservation biology, graduate education, interdisciplinarity.

RESUMEN

Así como la educación moldea los pensamientos de la siguiente generación de investigadores, sus marcos conceptuales, herramientas analíticas y la manera en que estos interactúan con su entorno natural, impactará significativamente los estudios científicos, las políticas y la toma de decisiones. El objetivo del presente artículo es analizar cómo los programas de postgrado en Chile, relacionados con ecología y manejo de recursos naturales, integran los aspectos socioecológicos en sus cursos de Biología de la Conservación. Adicionalmente, presentamos nuestras perspectivas acerca de los procesos, beneficios, y desafíos que se presentan con la participación en programas con enfoques interdisciplinarios. En Chile, revisamos 22 programas de postgrado (nueve doctorales y trece de magíster) relacionados con temas de ecología y/o manejo de recursos naturales, acreditados por la Comisión Nacional de Acreditación a octubre del año 2008. De ellos, el 64 % tienen un curso de Biología de la Conservación. A pesar de cierta integración de aspectos socioeconómicos en los contenidos de estos cursos, la perspectiva educativa de éstos sigue mayoritariamente el paradigma utilitarista, lo cual contrasta con las aproximaciones más amplias en la filosofía ambiental. Proponemos que es necesario un cambio de

paradigma en la enseñanza de la Biología de la Conservación en Chile, de tal manera que abarque aspectos sociales y ecológicos, más allá de su valor utilitario o instrumental, incorporando al ser humano dentro de los ecosistemas y el modelo ecosistémico del no equilibrio. Para integrar la perspectiva socioecológica en los cursos de Biología de la Conservación proponemos incluir 4 componentes en la enseñanza: (a) perspectiva biocultural, (b) interdisciplinariedad, (c) comunicación multidireccional y participación y, (d) experiencia de campo y encuentros directos con la naturaleza y las comunidades locales.

Palabras clave: biocultural, biología de la conservación, Chile, educación de postgrado, interdisciplinariedad.

INTRODUCTION

Conservation biology arose from a recognized need by scientists to study the impact of human activity on species diversity, biological communities, ecosystems and ecological processes with the objective of improving land management strategies (Vitousek et al. 1997, Sanderson 2002, Foley et al. 2005, Rozzi et al. 2006). In response to increasing homogenization of ecosystems scientists have been working to develop methodologies that enable sustainable management of natural resources for human and non-human well-being (Ehrlich 2002), but the success of initiatives that are able to account for the human well-being with the sustainability of the environment will depend upon the ability of researchers to understand the biotic systems as socio-ecological systems (Liu et al. 2007). This perspective motivates several initiatives to explore the multiple dimensions and interrelations which exist between social and natural systems and their natural and cultural components. In recent projects, like the Sub-Antarctic Biocultural Conservation Program, led by the Omora Ethnobotanical Park in Navarino Island (Chile), an interdisciplinary team of ecologists, philosophers and artists recognized this need within Conservation Biology, integrating a biocultural approach that consider the diversity in its biological, cultural and linguistic expressions (Rozzi et al. 2006b).

Here, we propose that in order to optimize and seek better understanding of processes in Conservation Biology, and to successfully incorporate human social and natural systems into one unit of study, it is necessary to analyze and redefine the fundamental framework and methodologies used to teach and form professionals in the discipline. This shift would further the paradigm shift that ecology has already undergone in the non-equilibrium model (Ostfeld & Pickett 1995, Pickett et al. 1997), incorporating environmental ethics values (Leopold 1949, Rozzi et al. 2008a) as a way of including the social component into ecosystemic studies. This requires studying our environment as a integrated system, not as isolated social or ecological systems, diminishing the hard line which separates 'soft' and 'hard' sciences of study. This approach considers ecosystems as human-natural systems, where ecological features are interrelated which human characters.

A socio-ecological approach clearly require an interdisciplinary focus, and for this reason a broad multi-faceted toolset to confront Conservation Biology and natural resource management challenges (Daily &

Ehrlich 1999; Ehrlich 2002). Following this argument, we consider that it is crucial to integrate not only socio-economic aspects with ecological principles throughout graduate education, but to open up the possibilities towards the broader realm of approaches from the humanities, including philosophy, music and other forms of human knowledge as well (Rozzi et al. 2008a, 2008b). This integration will allow students from these graduate programs to incorporate the broader realm of human experience and understanding and their different ways of communication, self-representation and environment perception.

During the last two decades, Conservation Biology courses have been established as a core course in a variety of universities, at both undergraduate and graduate levels throughout the world (Collett & Karakashain 1996). For example, in the United States of America, the majority of courses in this area are interdisciplinary, incorporating faculty from outside the biological disciplines (Jacobson 1990, Jacobson et al. 1995). However in Chile, this broad characterization is still absent. In this article, our objective is to analyze how Ecology and Natural Resources Management related graduate programs in Chile, integrate socio-ecological aspects in their Conservation Biology courses. Moreover, from our experiences as graduate students, we present our perspective about the processes, benefits and challenges that come with participating in interdisciplinary programs and courses which explicitly include this kind of interdisciplinary approach to environmental problems, proposing some components that we think are critical to the development of interdisciplinary courses. As we see, the incorporation of the human component in the courses of Conservation Biology can happen at two levels: i) a descriptive analysis of the anthropic impact in the ecosystem, and ii) the preparation of investigators as social actors with values and responsibilities within the study of ecological systems.

Graduate programs related with ecology and/or natural resources management in Chile

As of October 2008, 293 graduate programs were accredited by the Comisión Nacional de Acreditación (CNA) (National Commission of Accreditation) in Chile (117 PhD and 176 Masters). Twenty-seven of these were directly related to Ecology and/or Natural Resources Management. We selected a discretionary sample of 22 programs, equivalent to 80% of the total.

We analyzed the study plans available on internet of these programs. Fourteen (64%) of these included a course related to Conservation Biology. By email, we solicited the course's study plans or contents for our review. Tables 1 and 2 show a complete list of the surveyed programs.

Our review of the courses' contents revealed that the majority of these include the analysis of socio-economic indicators, as well as evaluations of natural resources management programs to explain the main causes of the present environmental crisis. Social aspects were integrated into the courses mainly through specific modules that study a certain area related with the social component. Examples are chapters such as "Biodiversity Threats and Land Use," "Study of Systems of Environmental Management," "Perception and Valuation of Biodiversity" or "The Roll of International Institutions (e.g., FAO, UN)"

However, in the reviewed programs, the integration of a conceptual and methodological frame of socio-ecological systems was not explicit (*sensu* Liu et al. 2007), which would allow for the formulation of

problems from an interdisciplinary perspective with research methodologies (Primack et al. 2006). From this perspective, the present graduate programs related to Ecology and Natural Resources Management subjects in Chile do not portray Conservation Biology as an interdisciplinary discipline that relates directly to the cultural diversity of the communities that inhabit natural systems (Primack et al. 2006). They consider Conservation Biology as an extension of Biology applied to the problems of biodiversity conservation (*sensu stricto*).

INTEGRATING THE SOCIO-ECOLOGICAL DIMENSION INTO CONSERVATION BIOLOGY CURRICULA

The present environmental crisis has demonstrated not only that the humans depend on natural ecosystems, but also that humans are a significantly important component of ecosystems. However, the development of traditional ecological model, or the 'equilibrium' ecological model, was centered on the ideal balance of

TABLE 1

Doctoral programs in biology, ecology or natural resources management accredited by CNA up to October 2008, according to university and conservation biology course, in Chile (S/I = without information).

Programas de doctorado en biología, ecología o manejo de recursos naturales acreditados por la CNA hasta octubre 2008, según universidad y curso de conservación biológica, en Chile (S/I = sin información).

Nº	University	Program	Course	Name	Professor
1	Pontificia Universidad Católica de Chile	PhD in Biological Sciences, Ecology (Doctorado en Ciencias Biológicas m/ Ecología)	No		
2	Pontificia Universidad Católica de Chile	PhD in Agricultural Sciences (Doctorado en Ciencias de la Agricultura)	Yes	Conservation Biology	Gloria Montenegro
3	Universidad Austral	PhD in Agricultural Sciences (Doctorado en Ciencias Agrarias)	No		
4	Universidad Austral	PhD in Sciences, Systematics and Ecology (Doctorado en Ciencias m/ Sistemática y Ecología)	Yes	Conservation Biology	Roberto Schlatter
5	Universidad de Chile	PhD in Sciences, Ecology and Evolutionary Biology (Doctorado en Ciencias m/ Ecología y Biología Evolutiva)	Yes	Ecology of Conservation Biology	Javier A. Simonetti
6	Universidad de Concepción	PhD in Biological Sciences, Botany (Doctorado en Ciencias Biológicas m/ Botánica)	Yes	Conservation Biology	Anibal Pauchard
7	Universidad de Concepción	PhD in Environmental Sciences, Inland Water Systems (Doctorado en Ciencias Ambientales m/ Sistemas Acuáticos Continentales)	Yes	Scientific Foundaitons for the Conservation of Aquatic Systems Ecology and Conervation of Fish	S/I
8	Universidad de Concepción / Universidad Austral	PhD in Forest Sciences (Doctorado en Ciencias Forestales)	Yes	Conservation Biology	Anibal Pauchard
9	Universidad de la Frontera	PhD in Natural Resources Sciences (Doctorado en Ciencias de Recursos Naturales)	Yes	Consevation of Soils and the Environment	S/I

nature. This paradigm viewed nature as having a specific state that was self-regulating and that this state was unrelated with other components in the systems, such as the anthropogenic change (Ostfeld & Pickett 1995), excluding humans from closed natural systems. This model, also referred to as the pristine model of nature, considers humans as unnatural and harmful beings for the environment, and likewise, concludes that human beings must physically be outside the conservation areas to prevent damage to ecological processes.

The development of a non-equilibrium paradigm has allowed for research to begin considering human communities and their influence on the environment as part of the dynamics of ecosystems (Pickett et al. 1992). With increasing anthropogenic pressures that significantly alter the dynamics of ecosystems and the composition of biodiversity, the pristine ecological

model does not address the needs of Conservation Biology and the management of natural resources because it excludes the human component from the ecosystem. It is clear that ecological ecosystems and processes are not limited to political territories or the units chosen for research, and further, that anthropogenic impacts cannot be contained by territorial lines drawn on a map. Yet, the main efforts to describe the value of ecosystems and biodiversity have mostly been conducted from a utilitarian perspective which focuses on the economic value of nature in terms of human consumption (Constanza et al. 1997). The consequence of this is that monetary value is equivalent and indicative of the real value of those resources.

In order to solve such limitations, different authors have emphasized the importance of the interdisciplinary work to support the development of new scientific research agendas for Conservation

TABLE 2

Masters programs in biology, ecology or natural resources management accredited by CNA up to October 2008, according to university and conservation biology course, in Chile (S/I = without information).

Programas de magíster en biología, ecología o manejo de recursos naturales acreditados por la CNA hasta octubre 2008, según universidad y curso de conservación biológica, en Chile (S/I = sin información).

N°	University	Program	Course	Name	Professor
1	Pontificia Universidad Católica de Chile	Masters of Animal Science	Yes	Conservation Biology	Gloria Montenegro
2	Pontificia Universidad Católica de Chile	Masters of Plant Science	Yes	Conservation Biology	Gloria Montenegro
3	Universidad Austral	Masters of Science, Animal Production	No	Plant Genetic Resources Conservation	
4	Universidad Austral	Masters of Plant Science	Yes	Conservación de Recursos Genéticos Vegetales	Andrés Contreras
5	Universidad Católica del Norte	Masters of Marine Sciences, Coastal Resources	Yes	S/I	Carlos Gaymer
				Conservation of Vegetation and Flora	S/I
				Conservation and Study of Animal Populations	S/I
6	Universidad de Chile	Masters of Nature Conservation in Wildlife Areas	Yes	Conservation and Integrated Management of Soil and Water	S/I
				Ecophysiology for the Conservation and Vegetation Management	S/I
7	Universidad de Chile	Masters in Biological Sciences	NI		
8	Universidad de Concepción	Masters of Science, Botany	Yes	Conservation Biology	Anibal Pauchard
9	Universidad de Concepción	Masters of Science of Fisheries	Yes		
10	Universidad de Concepción	Masters of Science of Zoology	Yes	Topics about Conservation Biology	Juan C. Ortiz
11	Universidad de la Serena	Masters in Biological Sciences, Arid Zone Ecology	Yes	Conservation Biology	Francisco A. Squeo
12	Universidad de Talca	Masters in Horticulture	No		
13	Universidad de Tarapacá	Masters in Biological Sciences	No		

Biology and valuation of nature (Lubchenco et al. 1991, Daily & Ehrlich 1999). Here, on the basis of our experiences and on the methodologies of education from the field courses in conservation part of the Sub-Antarctic Biocultural Conservation Program of the Omora Ethnobotanical Park (Rozzi et al, 2010), we propose four components in order to integrate the socio-economic, ethical and biological aspects in courses and programs of postgraduate/graduate study in Conservation Biology. Such additions will help conservation educational programs to overcome the dominance of the utilitarian approach within ecological studies that largely influences scientists and policy-makers within these disciplines. This proposal consists of developing educational standards and theoretical concepts for interdisciplinary work, which will be reflected in the creation of methodologies for practical activities in courses that contextualize and promote interdisciplinary learning. This shift will expand current methodology to include 4 components, which reflect the integration of the human component in two levels: descriptive and reflective. These additional four components are: (i) biocultural perspective, (ii) interdisciplinarity, (iii) multidirectional communication and participation, and (iv) field experience and direct encounters.

Biocultural perspective

The integration of the social, economic and cultural aspects into Conservation Biology research requires scientists to adequately address both the human and biological dimensions of ecosystem health (Daily & Ehrlich 1999). For example, studies reveal that there exists a correspondence between a high linguistic and biological diversity (Sutherland 2003), moreover Primack et al. (2006) have shown how human communities had co-evolved with their local ecosystems, developing particular ways to describe, relate and co-exist with them. This connection and interrelation between biological and cultural diversity has been termed biocultural diversity and is an expression of recognition to the intrinsic link between the diversity of human cultures, languages and ecosystems (Maffi 2001, Rozzi et al. 2006b). For example, in the north-central Chile, the extensive use of the natural pastures by goats has a significant impact on the vegetation, which generates a conflict of environmental interests between conservation demands of native flora and the needs of subsistence of local communities in those arid ecosystems. A biocultural approach to this scenario, would consider not only the development of strategies to handle the ecosystems in terms of productivity (a classic management approach), or of absolute exclusion of natural prairies from human use (a classic conservation approach), but would consider strategies that integrate the traditional ecological knowledge of the local community, along with their cultural practices, that would benefit prairies such as rotation of the use of prairies through movement of the cattle

(transhumance) (Erazo 2009). Understanding the ecosystems in terms of its biological and cultural aspects is an approach that we considered more appropriate for conservation because it also facilitates decision-making in the management of natural resources (Maguire 2004).

Interdisciplinarity

The development of the concept of biocultural conservation, as a theoretical and practical model, allows integrating natural sciences with philosophy (Rozzi et al. 2008b). Nevertheless, to analyze social and ecological systems as one unit itself requires developing interdisciplinary educational programs and natural resources management strategies that approach both social and ecological concerns simultaneously. The effect of this kind of work is multiple and has impacts on the research results as well researcher themselves. For example, Sung et al. (2003) propose that interdisciplinary culture must influence lives of scientists as part of their own academic formation. This promotes collaboration to develop work groups and facilitate better communication (Graybill et al. 2006). On the other hand, interdisciplinarity adds to a diversity of knowledge and perspectives that help to perceive different dimensions of the environment and its problems. In the development of graduate programs, we recommended that these processes can be enriched by incorporating foreign graduate students or students with experience in other knowledge areas. Nevertheless, in order for this integration to be effective across disciplines, it will require this participation to be in an equal level with biologists, which implies a deep change in ecologists' and biologists' conservation academic culture.

Multidirectional communication and participation

In order to allow this cultural shift and achieve an interdisciplinary research, one of the biggest hurdles is establishing effective communication (Daily & Ehrlich 1999). For example, the epistemological isolation of the disciplines within biological sciences and philosophy diminishes the communication between specialists (Rozzi & Feinsinger 2006). Establishing fruitful ways of dialog between biological sciences, social sciences and humanities is complicated, but even more difficult is to achieve a real link with non-academic society, because each discipline develops its own technical language (Redman 1999). In the creation of graduate courses and programs, this integration could be developed not only by fortifying links among student and academics but also the link between students and other society members. For this, it must be promoted formal (e.g., coursework within schools, interdisciplinary field courses) and informal (e.g., community work groups, student's associations) instances of interaction and knowledge exchange, that allow graduate students to better communicate with a diverse group of people- a

prerequisite for confronting and solving future environmental conflicts. From our experience, the model developed by Omora Ethnobotanical Park in the Cape Horn Biosphere Reserve has constituted a space where scientific knowledge coexists with local community knowledge with the aim of improving the processes of biodiversity conservation, in harmony with customs and traditions of local inhabitants (Rozzi et al. 2005). At same time, Omora Park programs have enabled group of students (including the authors of this article) to know each other, interact and generate interdisciplinary research from diverse countries, backgrounds and languages.

Field experience and direct encounters

Finally, we would want to underline the importance of field experience and “direct encounter” between students and academics with human communities that inhabit places of high ecological value. This component arises as a key step for the education of graduate students from a biocultural approach, since it allows them to have direct experiences not only with their surroundings (object of traditional study) but also with local communities (the broader social context of ‘ecosystem’) which use the resources that their search to conserve. This method of learning counterbalances the excess of mediated information that we receive through other sources (e.g. scientific publications, mass media), that can distort our appreciation of nature and the use of natural resources by local communities (Rozzi et al. 2006b).

It is necessary to generate programs and field courses that have a temporal continuity and the necessary funding for this development. For this reason, the existence of the Long-Term Socio-Ecological Research (LTSER) sites are fundamental to facilitate these direct encounters with nature and communities, and to gain direct experience in research and conservation (Anderson et al. 2008). One of the missions for this Chilean LTSER network was to conduct research capable of promoting the development of programs related to sustainable ecological and social well-being (Anderson et al. 2008). From this perspective, the Conservation Biology researchers cannot just engage nature as a study object, but also they must bring this level of engagement to their actions as members of a society on environmental risk.

CONCLUDING REMARKS

The famous ecologist and conservationist Aldo Leopold criticized a strict utilitarian model of valuation, because it did not consider the relation between human and nonhuman entities. In addition, Leopold argued that this approach does not include recreational, aesthetic and emotional values that society attributes to the environment and for that reason he proposed a new conservation ethics, which extend the limits of the

community to include soil, water, plants and animals, or as he called it collectively: the land (Leopold 1949).

Today we recognize that, educative models mold the type of research carried out by conservation biologists and helps to inform to decision-makers, when they seek a broader understanding of the consequences of management strategies. By this, biologists and ecologists who focus their investigation in the processes that affect or promote the conservation of biodiversity should need to evaluate the biological and cultural components of ecosystems and units of study. This will facilitate their ability to communicate these values in scientific, educational and policy-makers arenas. The paradigm shift in ecological sciences and biodiversity conservation towards a socio-ecological and/or biocultural perspective requires current framework and methodologies to incorporate this new approach in education, as well as in its practical application.

Considering Aldo Leopold’s argument that an ecological conscience emerges with knowledge of the ecosystem and direct experience, we can reflect on the importance of the content of conservation biology coursework, and its consequent impact on the relevancy of the field for addressing conservation management strategies: “Conservation is a state of harmony between men and land. Despite nearly a century of conservation propaganda still proceeds at a snail’s pace; progress still consists largely of letterhead pieties and convention oratory... The usual answer to this dilemma is ‘more conservation education’. No one will debate this, but is it certain that only the volume of education needs stepping up? Is something lacking in the content as well?” (Leopold 1949).

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