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Three levels of integrating ecology with the conservation of South American temperate forests: the initiative of the Institute of Ecological Research Chiloé, Chile

RICARDO ROZZI[1,2,*], JOHN SILANDER JR[2], JUAN J. ARMESTO[1,3], PETER FEINSINGER[1,4] and FRANCISCA MASSARDO[1]

*[1]Institute of Ecological Research Chiloé, Chile; [2]Mailing address: Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT 06269-3043, USA; [3]Laboratorio de Sistemática y Ecología Vegetal, Facultad de Ciencias, Universidad de Chile. Casilla 653, Santiago, Chile; [4]Northern Arizona University, Flagstaff, AZ 86011, USA; *Author for correspondence (e-mail: rmr96002@uconnvm.uconn.edu)*

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Abstract. The diversity of native species assemblages and that of indigenous cultures that once characterized the temperate forests of southern Chile have experienced a process of homogenization ever since the Spanish conquest. Today this process continues to erode both biotic and cultural diversity. With the goal of linking ecological research with actions to conserve the biological and cultural richness of this region, we established the Institute of Ecological Research Chiloé. The Institute's philosophy and activities involve three approaches: (1) participation of professional ecologists in environmental education and decision making, through collaboration with the community at local, regional, and global scales. (2) programs of ecological education, which include planting indigenous trees in urban areas and creating a local botanical garden with representative Chilean forest species. (3) critical analyses of the narrow economic and utilitarian environmental ethics that currently prevail in Chile, and often in other Latin American nations, and examination of traditional or novel alternative ethics and perspectives that address multiple interrelations between biological and cultural dimensions.

Key words: biological and cultural diversity, ecological education, environmental values, South American temperate forests, sustainable biosphere initiative

Introduction

During the last five centuries, science and technology inspired by a Western conception of progress have played a major role in the cultural and biological homogenization of the unique and heterogeneous landscapes of the New World. An example of this is the South American temperate forest biome. To comprehend and deal with the losses of biodiversity, environmental and social problems that result from homogenization, we adopt the interdisciplinary perspective presented in the symposium *Concepts of Nature: The Social Context and Ethical Implications of Ecology* (INTECOL 1998) with the goal of developing novel methods for integrating

ecological and cultural conservation. Purely technical or scientific approaches do not address primary causes of environmental problems, and are insufficient for implementing long-term preservation and/or restoration of the diverse landscapes of southern South America (see Rozzi et al. 1994, 1997, 1998a; Primack et al. 2000). In this paper, we begin by presenting an overview of the biological, ecological and cultural diversity of the South American temperate forest biome, and documenting historical changes in the land and their inhabitants since the arrival of the European to the region. Then, we describe the approach of the Institute of Ecological Research Chiloé (IERCH), whose philosophy aims to brake, and even reverse, the regional rapid process of homogenization. An independent academic entity created in 1994, IERCH, seeks to integrate ecological research with environmental and social issues that affect the temperate forest zone of southern Chile (see Armesto et al. 1996a; Rozzi and Armesto 1996).

Overview of biogeographical and ecological attributes of South American temperate forests

The South American temperate forests are distributed in a long, narrow strip of land on the southwestern edge of the continent. The forests zone stretches nearly 2000 km, from to south-central (35° S) to southern Chile (55° S), and for a shorter length on the eastern slope of the Andes in Argentina (Figure 1). Temperature and rainfall regimes vary considerably through this zone (Arroyo et al. 1996). A complex topography, which includes the Coastal and Andean ranges, the Central Valley of Chile, and the southern Archipelago and Channel regions generates further environmental heterogeneity. The temperate fauna and flora also have diverse origins, in particular the two divergent Neotropical and Gondwana biotas (see Axelrod et al. 1991; Villagrán and Hinojosa 1997). The joint effects of climatic, topographic, and biogeographic variation result in a remarkably diverse suite of ecological forest types that range from open palm parklands dominated by the endemic *Jubaea chilensis*, to the floristically and structurally complex Valdivian rainforest, to the drier highland forests of the pehuén or monkey-puzzle tree *Araucaria araucana*. Depending on the classification system used, between 12 and 25 major forest community types exist within the South American temperate forest biome as a whole (see Veblen and Schlegel 1982; Donoso 1993; CONAF 1997). Any prospective conservation program for this diverse biotic landscape must consider each of the particular forest ecosystems in the mosaic, and the interrelations among these. Programs that treat the region as a unified whole can be quite counterproductive (see Armesto et al. 1998).

Another important characteristic of the South American temperate forest region is that it represents a singularly isolated biome at the southern extreme of the continent. Great orographic and climatic barriers separate the biome from the nearest tropical forests, by 1500 to 2000 km. To the north lie Mediterranean-type

Figure 1. The temperate forest region of southern South America (in dark), showing the location of the headquarters of the Institute of Ecological Research Chiloé (IERCH) (*) and its logo. The IERCH's triangular logo was adopted from the Sustainable Biosphere Initiative (SBI) philosophy that called for ecological scientists to involve themselves directly with educators and environmental decision-makers. We added to the SBI's figure bidirectional arrows to underscore IERCH's emphasis on a collaborative and participatory approach, avoiding the hegemonic role assigned to science for the interactions.

scrublands and the Atacama Desert, one of the driest in the world. To the east, beyond the Andes range, lies the vast, dry Patagonian steppe of Argentina. Westward and southward lies the Pacific Ocean. This insularity has promoted the evolution of a largely endemic biota. Close to 90% of the woody species are endemic to the temperate forest region. A third of the 84 woody genera are endemic, and of these 24 are monospecific (Arroyo et al. 1996). Among the monospecific genera of trees, some notable examples are the 'southern redwood' *Fitzroya cupressoides*, which can attain an age of more than 3600 years and which may be the second longest living tree species in the world (see Lara and Villalba 1993), and *Aextoxicon punctatum*, the only representative of the relict family, Aextoxicaceae. Among vertebrates (invertebrates are very incompletely documented) 147 species are endemic. Again levels of endemism are quite high for a continental system: 50% of fishes (26 spp.), 80% of amphibians (30 spp.), 36% of reptiles (16 spp.),

30% of land birds (44 spp.), and 33% of mammals (33 spp.) (Armesto et al. 1996b, Simonetti et al. 1996).

Not only is the biota inhabiting this mosaic of temperate forest ecosystems unusual, but so are several community- and ecosystem-level processes. The frequency of plant-animal mutualisms, particularly related to seed dispersal and pollination, is exceptional for temperate forests (Willson 1991; Aizen and Ezcurra 1998). A surprisingly high percentage (67%) of plant species have fleshy fruits and avian seed dispersal, and more than 50% of the plant species require a biotic pollinator (Armesto and Rozzi 1989; Rozzi et al. 1996; Willson et al. 1996; Aizen and Ezcurra 1998). At the ecosystem level, forest watersheds display a high capacity for nutrient retention (Soto and Campos 1996). Precipitation is less polluted than for any other of the world's temperate forests (Likens 1991), and the virtual absence of chemical pollution in soils and streams make these ecosystems uniquely suited for comparative ecological studies of biogeochemistry (Hedin et al. 1995).

Overview of the cultural diversity and history in the South American temperate forest landscape

The South American temperate forest biome has supported not only unique ecosystems but also a mosaic of idiosyncratic and diversified indigenous cultures (Cooper 1946; Hidalgo et al. 1997). Among these were the world's most southerly pre-Colombian inhabitants, living at 55° S in Tierra del Fuego. Due to isolation from the Inca and pre-Inca civilizations of the central Andes, and from the Mapuche cultures of the northern areas of the South American temperate forests, as well as by the rigorous climatic conditions, the Yamana, Alacaluf and Ona groups inhabiting this forested archipelago and channel region (43–55° S) reached the 20th century with essentially an intact Paleolithic culture (Chapman 1981). Lamentably, these three groups, together with the Chonos who inhabited the Archipelago of Chiloé at 41–43° S, are now nearly or completely extinct (see Aylwin 1994, 1995).

To the north of the southern archipelago region, between 35–41° S but still within the South American temperate forest biome, one can still find quite different indigenous communities of the Araucanians or Mapuche (Mapu = land; che = people). At present, three main sub-groups occupy distinct forest types: the Pehuenche (people of the Pehuén), closely associated with forests of *Araucaria araucana*; the Lafkenche (people of the sea or Lafken), associated with the coastal forests of central southern Chile and also dependent on marine resources (algae, mussels, fish); and the Huilliche (people of the south or Huilli), associated with evergreen rainforests extending from the Río Toltén (38° S) south to Chiloé Island (42° S).

Since the Spanish arrival in Chile in 1537, the forest landscape and its associated indigenous cultures have experienced three main waves of transformation. The first wave of contact by and establishment of the Spanish during the 17th and 18th centuries brought the spread of virulent epidemics, the direct slaughter of indigenous

people, and the introduction of horses and cattle (Bengoa 1985). Farther to the north, large expanses of sclerophilous and deciduous forests in central Chile were burned in order to open up land for agriculture. The Spaniards also increased drastically the extraction of forest trees for construction, furniture, and fuelwood (Donoso and Lara 1996).

A second wave of intensive transformation began after Chile gained independence from Spain and reached its maximum intensity during the second half of the 19th century. The Chilean government organized massive campaigns to promote the immigration of European colonists, especially German farmers. With the goal to 'develop' the country (see Pérez-Rosales 1882), between 1860 and 1900 German immigrants burned great expanses of forest in Chile's lake region (39–42° S), opening up land for agriculture and cattle (see Schmalz 1970, 1971, 1972; Ilg 1982). Concurrently, the Chilean government undertook a singleminded military campaign to 'pacify' the Mapuche. These indigenous groups had fiercely and successfully defended their lands since before the arrival of the Spanish but could no longer prevail against the well-armed Chilean military, finally surrendering in 1883. As was happening simultaneously across the Andes in Argentinean Patagonia and far away in the western United States, these nomadic or semi-nomadic peoples were quickly herded onto marginal reservation lands while the most productive regions of their former territories were granted to colonists from the north and south, or to German, Italian and Swiss immigrants (Aylwin 1994). Within two or three decades, the colonists had developed extensive monocultures of wheat whose consequential landscape degradation, including erosion problems, persist today (Donoso and Lara 1996). The southernmost extreme of the forest region (53–55° S) also began to attract national and European colonists, including Yugoslavs and Scots, who initiated the large-scale sheep ranching that drastically changed the landscape by the end of the 19th century. The indigenous Fuegians, nomadic hunters and gatherers, were slaughtered and displaced from their lands (Mayorga 1972). With forest clearing, landscape conversion, new diseases, alcoholism, and acculturation, the indigenous populations of the Ona, Alacaluf, and Yamana peoples had nearly vanished by the middle of the 20th century (Aylwin 1995).

The third wave of transformation of the natural landscape and social order of southern Chile began in the mid 20th century with the development of the forest plantation industry and with campaigns to fully assimilate the indigenous cultures into Chilean society. Since 1940, Chilean forestry has become increasingly dependent on plantation monocultures of the Monterrey Pine (*Pinus radiata*), at the expense of native forests. The latter continue to be clear-cut and burned to be replaced by the plantations, and during the last two decades the Chilean government has accelerated this process through subsidies (Decree 701), and massive development of *Eucalyptus* plantations (Lara et al. 1996; Armesto et al. 2000). With the transformation of native forests into homogenous plantations of exotic trees, living conditions of the Mapuche have declined dramatically. Life within the reservation system became increasingly difficult due to population growth and soil erosion associated

with imported agricultural practices (Harttwig 1976). The environmental deterioration forced many Mapuche to migrate to marginal urban areas (Aylwin 1994). Beginning in 1974, the situation was further aggravated by increased expropriation of ancient lands and the subdivision of Mapuche communities (Decree 2568; see Aylwin 1994; Molina and Correa 1996a,b). During the 1970s and 1980s, Chile's military regime enforced programs to replace the traditional rucas (Mapuche huts) with modern houses, and to eliminate the Mapudungun language from formal and informal education; only Spanish was allowed (see Berdichewsky et al. 1977).

The conservation initiative of the Institute of Ecological Research Chiloé (IERCH)

In Chile, conservation efforts based solely on protected areas are insufficient to divert the current trajectory of environmental degradation and the losses in diversity both biological and cultural. Yet, during the 20th century conservation efforts in Chile have focused almost exclusively on the creation and management of protected areas. Indeed, the Chilean system of protected areas (SNASPE), one of the oldest in Latin America, is touted as an exemplary model because it involves as much as 29% of the land area at the latitudes where temperate forests exist (Ormazábal 1988). Nevertheless, with respect to long-term conservation, SNASPE faces serious limitations on at least three fronts.

First, the geographical distributions of protected areas and the diverse, forested landscapes do not overlap extensively. More than 90% of the land area protected lies below 42° S, outside those regions with the highest endemism and species richness. Most protected areas are defined on 'unproductive' cheap land, or emphasize starkly beautiful but nonforested landscapes, following the paradigm for creating many national parks in the North Temperate zone: 'scenery, not biodiversity'. The few national parks and other, smaller protected areas north of 42° S are threatened by their intensively managed surroundings of exotic tree plantations, agriculture, and village or urban lands, as well by natural disturbance events – volcanism and extensive landslides caused by earthquakes (Armesto et al. 1998).

Second, within and outside of protected areas conservation laws are frequently ineffective, due to a lack of public comprehension, to a lack of firm commitment by the government, or to insufficient resources and personnel for enforcement. For example, the monkey-puzzle tree or pehuén (*Araucaria araucana*), not only one the most charismatic tree species of Chile but also the basis of subsistence and spiritual life for the Pehuenche people, was declared a National Monument in 1976. Yet today illegal cutting continues even within the boundaries of national parks (Aagesen 1998). Analogously for endangered fauna, such as the Chilean freshwater and sea otter (*Lutra provocax* and *L. felina*), illegal hunting for fur trade still continues clandestinely, reducing their abundance and range (see Rozzi and Torres-Mura 1990; Glade 1993).

Third, today's economy and culture in southern Chile are based largely on exotic species. During the past decade, more than 90% of the milled wood exported by Chile was from *Pinus radiata* (INFOR 1997), 80% of the plant species used by the Chilean natural products pharmaceutical industry are exotics (Massardo and Rozzi 1996; Massardo 1997), and today central plazas of cities in southern Chile are dominated by exotic tree species (Rozzi and Armesto 1996). Textbooks used in Chilean schools between 1975 and 1995 emphasized the flora and fauna from distant regions, especially Europe. Fewer than 20% of the illustrated or described examples were of native plants or animals (R. Rozzi, unpublished data). Even now, the rich traditional knowledge of botany and zoology are not mentioned in Chilean school or university programs in ecology (Grez et al. 1995). We do not advocate 'xenophobia' directed against exotic species or foreign cultures as do some ecologists or philosophers (see Eser 1998), but we attempt to give appropriate weights to native biotas, regional ecosystems, and traditional practices.

To counter the uncontrolled substitution of diverse natives with a few exotics, to re-diversify the increasingly homogeneous landscapes created by contemporary Chilean society, and to protect biodiversity in the long term, we consider it critical to supplement conservation programs restricted to protected areas with (1) programs that involve the full gradient of ecosystem alteration, from isolated wilderness areas and national parks through rural landscapes to urban ecosystems (Rozzi et al. 1994; Willson et al. 1994; Armesto et al. 1996a); (2) formal and non-formal educational programs at all levels that incorporate an understanding of the native biota, including proactive analyses of the cultural causes and historical processes that have eroded both the cultural and biological diversity (Rozzi 1997, 1999; Rozzi and Massardo 1999); and (3) efforts to transform current social attitudes and practices detrimental to those landscapes, through direct collaboration with local communities outside protected lands (Rozzi and Armesto 1996). With the goal of implementing this three-pronged approach to conservation, in 1994 we created the Institute of Ecological Research Chiloé (IERCH).

Biological station 'Senda Darwin'

We established a biological station on the main island of Chiloé (Figure 1) not only for ecological research but also to facilitate sustained interactions with the local communities. We chose the name Senda Darwin because the path Charles Darwin walked during his extensive visit to Chiloé in 1834 can be still traced across the 80 ha property (Armesto et al. 1996a; Willson and Armesto 1996). The decision to locate the Biological Station on Chiloé was based on 15 years' experience of Chilean and foreign researchers, associated with the Plant Ecology Laboratory of the Universidad de Chile, on Chiloé. The research provided a unique start-up database on the biota, ecosystems, and ecological processes of the region. Also, Chiloé is conveniently

located at the geographical center of the temperate forest region (Figure 1) and is a transitional area between the heavily converted areas to the north and less altered landscapes to the south. The west coast of the island includes the National Park of Chiloé, whose 43 000 ha constitute the only extensive protected area in the Chilean coastal forest ecosystems that escaped Pleistocene glaciations.

The archipelago to which Chiloé belongs includes about 40 islands, most of them inhabited. Chiloé itself, or more accurately La Isla Grande de Chiloé, is the second largest island of South America (after Tierra del Fuego), 250 km long with a mean breadth of 50 km. The landscape of Chiloé is a mosaic of deforested areas often with intensive agriculture or livestock, and areas of nearly pristine forest. Its small population of 110,000 (about 67,000 in rural areas) is far from homogeneous. Local communities reflect the unique culture that since the conquest have developed almost in isolation from continental Chile. Some communities of the indigenous Huilliche (see above) still exist. The subsistence economy is still based on artesanal harvesting of marine resources and small-scale agriculture, particularly potatoes, but the development of logging, salmon-farming, and tourist industries lead to a rapidly-growing cash economy. The Biological Station Senda Darwin facilitates the collaborations described below between ecologists of the IERCH and the various local communities.

The conservation program of the IERCH

The conservation program of the IERCH involves three complementary lines. (1) with the goal of engaging in ecological problem solving, IERCH brings together individuals and institutions with diverse points of view and coordinates these efforts at local, regional, and international scales. (2) personnel of IERCH focus research, applications, and education on the complex interactions between human communities and the regional ecosystems they occupy. (3) IERCH also emphasizes participatory research and education on the interrelations between cultural and biological diversity, and on those between the ecological sciences and environmental ethics. Our objective has been to extend ecological research beyond academics towards a proactive role in conserving the ecological and cultural landscapes of the region.

Collaborative approaches to conservation at the local scale

This line of activities was inspired by the Sustainable Biosphere Initiative (SBI) developed by the Ecological Society of America (Lubchenco et al. 1991; Vitousek 1994). The SBI proposed an agenda for ecological research and called for ecological scientists to involve themselves directly with educators and environmental decision-makers. Although the SBI has been severely criticized as being at once self-serving and utopian (e.g., Ecological Applications 1993: 545–586), to us the basic concept of the SBI was compelling. IERCH not only adopted the basic philosophy of SBI

but also the triangle of the IERCH logo reflects the SBI: ecological research, environmental education, and the applications of ecology towards developing a sustainable relationship between society and its environment (Figure 1). On Chiloé, individual ecologists had already begun to disseminate ecological knowledge on the regional biota. With the establishment of IERCH began more systematic interactions with schoolteachers and students, with personnel of national parks, and with personnel of governmental and non-governmental organizations involved in environmental decision making and regional planning in southern Chile (Rozzi and Armesto 1996).

Soon thereafter, we substantially modified the SBI approach. The SBI (Lubchenco et al. 1991) called for "(1) basic research for the acquisition of ecological knowledge, (2) communication of that knowledge to citizens, and (3) incorporation of that knowledge into policy and management decisions" – that is, a unidirectional communication of ecological knowledge. Our initial workshops and educational activities at IERCH, quickly demonstrated that a bi-directional, participatory approach was far more effective. Rather than simply communicating ecological knowledge amassed by 'bona fide' ecologists, we established a dialogue and working protocol with teachers, park rangers, foresters, and decision-makers. Symbolically speaking, we modified the original SBI triangle (Lubchenco et al. 1991; Figure 3) by adding bi-directional arrows (see Figure 1) to underscore IERCH's new emphasis on collaborative learning, brainstorming, and decision-making processes regarding conservation action: "conservation in conversation" (Evernden 1992). Thus, although SBI's call for integration among research, education, and decision-making still forms the philosophical core of IERCH's approach, the mechanism is participatory rather than top-down.

Let us now consider the change in approaches derived from ethical, cultural, and pragmatic considerations. First, imposing a top-down, academic approach to ecology and conservation – an approach largely developed in other landscapes – would, on Chiloé (and elsewhere), be hypocritical and unethical. In some respects such an importation would be just one more wave of intellectual and practical suppression, little different ethically from the three previous waves of southern Chile's transformation. In contrast, the non-hierarchical interactions we proposed were intended to respect and incorporate the diverse viewpoints of local people, with their own histories and values.

Second, it follows that modern science is only one of many cultural dimensions contributing to knowledge about, and relationships with, the natural environment. In southern Chile, as in some other Latin American regions, indigenous cultures have inherited a sophisticated body of traditional knowledge (see Stevens 1997). On Chiloé proper, the unique 'Chilote' culture that evolved from the mix of indigenous peoples and Spanish colonists has, of necessity, been well integrated into the region's idiosyncracies. Examples include Chiloé's unusual wood-shingle architecture, extensive use of indigenous plants to dye the wool used in weaving, and local diets that include leaves of native plants, numerous endemic varieties of potato, forest mushrooms, algae, fish, and shellfish as well as pigs, chickens, and oat or wheat flour

introduced by the Spaniards (see Cárdenas 1989). An exclusive focus on top-down dissemination of scientific ecology would risk ignoring or even oppressing these and many other cultural traditions.

Third, the pragmatic benefits of participatory approaches derive from higher degrees of commitment by local communities. In Chiloé, as elsewhere in Latin America at least, respect for the 'hearts and minds' of local people and for their contributions to environmental projects instills a sense of pride and 'ownership'. Through this process, local people (and ecologists from outside!) are encouraged to think independently and to reflect profoundly on their relationship with the environment. True local participation represents a critical component, perhaps the most critical, of the long-term success of sustainable conservation projects (Altieri and Masera 1993; Princen and Finger 1994).

Past conservation programs in the 'Third World' have frequently failed simply because ecologists arrived from outside ready to teach local people and institutions how to solve their problems, based on models developed elsewhere (Abu Sin 1991). Alcorn (1991) asserts that this attitude has squelched a great deal of local cultural richness, including traditional forms of relationship with the local environment that may end up conserving biodiversity. Contrary to the fundamental goals of conservation programs, the importation and imposition of 'scientific' approaches may introduce new cultural values that actually increase material aspirations and rates of consumption by local communities, or may discourage community involvement (Alcorn 1991; see also Shaxson 1991; Toulmin 1991). One of the most telling results in Chiloé has been the effectiveness of arriving in the landscape and then collaborating with ongoing projects already initiated by local people. For example, by joining a project of the rural school Sol del Pacífico we learned about traditional methods of collecting sea-weeds and mussels while at the same time we helped the school to obtain access to a local bay and to incorporate ecological analyses of these activities in its educational curriculum. Instead of importing new projects from outside, we can encourage extant practices or projects with positive implications to biodiversity conservation, in essence, acting as 'catalytic agents' or collaborators in these local initiatives.

Integrating local, regional-national and international viewpoints

A conservation plan that involved the local scale exclusively would risk being subsumed by national or international policies. For this reason IERCH attempts to maintain communications and working relationships with decision-makers or institutions at not only local but also regional and global scales, in this sense incorporating 'top-down' with 'bottom-up' approaches to biodiversity protection (see Feinsinger 1996). When IERCH began participating in conservation programs already underway on Chiloé, we also began to propose and design means of coordinating those initiatives with programs and policies at national and international levels. For example, at

the local level IERCH works with teachers and students in developing programs of ecological education. At the national level IERCH collaborates with the Ministry of Education in preparing curricula and educational materials that include the natural history of Chilean ecosystems and landscapes. At the international level, IERCH exchanges experiences with analogous ecology education programs in other Latin American countries (Feinsinger et al. 1997), the SYFEST program in North America (Berkowitz and Feinsinger 1997), and educational programs at the Royal Botanic Garden of Edinburgh, in the UK (Baxter et al. 1998).

Simultaneous work at several scales can contribute not only to solving environmental problems but also to understanding their origins. The two main consortia involved in exploiting Chilean forests are the Japanese conglomerate Mitsubishi-Daio Paper-Marubeni and the multinational entity of Citibank-Scott Paper-Shell (Wilcox 1995). Inexplicably, the analyses of conservation problems done by Chilean ecologists and social scientists often fail to address the ultimate role of the international dimension. Instead they focus on proximal causes, criticizing non-sustainable practices of local people as both the ultimate and proximate cause of landscape degradation. In truth, over the past decade the increase in southern Chile's production of wood chips, usually from native forests, closely tracks the curve of Japanese demand for this product (Claude 1997), which, in turn, closely resembles the rate of increase in illegal forest clearing. The net result has been an annual loss of around 120,000 ha of Chile's native forests during the 1990s (Lara et al. 1996). Wood chips constitute fully 45% of the exported volume of wood products but $<5\%$ of the total income generated by exported wood products, and $<5\%$ of the work labor occupied by the Chilean forestry activity (Claude 1997). Worse, recent export prices of native wood chips (US$55/ton) are lower than eucalyptus chips (US$75/ton; INFOR 1997). The wood-chip industry's low compensation to Chile, and the facts that 93% of the native chips are exported, and that $>55\%$ of the industry involves only the two international consortia, cries out for critical analyses of the national and global dimensions of Chile's deforestation and the environmental problems associated. Local, regional and international conservation efforts must collaborate if irrevocable degradation of South American temperate forests is to be avoided.

Incorporating ecological understanding into education and landscape design

In analogous fashion, human intervention in southern Chile's landscapes involves all scales, from the subtle influence of global change on 'natural' local ecosystems such as Chiloé National Park to the obvious influence of local activities such as intensive agriculture, pine and eucalyptus plantations, salmon farms, dams, and cities (Rozzi et al. 1994). Likewise, the full gradient of landscapes on Chiloé incorporates numerous influences – subtle or not so subtle – of past and present human activities. Avoiding the naïve dichotomy between 'natural' and 'artificial' ecosystems

enables us to better understand the role of humans in transforming and modifying Chiloé's landscape. At the same time, acknowledging that ecosystem functions are continuously affected by human activity poses a new task for IERCH. Rather than simply describing and trying to understand ecological processes, we must also focus on designing the ways in which present-day human communities can interact with, transform, and restore the environment.

IERCH's educational programs on Chiloé illustrate how ecological understanding can be incorporated into research, education, and application. We work with schoolteachers and children in three areas (see Rozzi and Armesto 1996). First, the collaborative development of school programs that emphasize ecological inquiry in the everyday environment foster the capacity to observe, formulate questions about the local environment (in particular, the plants, animals, microhabitats, and human effects found within the school yard); answer those through first-hand inquiry; reflect, and in some cases apply the conclusions – while at the same time learning about the natural history of local species, habitats, and human 'footprints'. The pedagogical approach involves independent thought and field experience while avoiding as much as possible the scientific jargon and 'cookbook recipes' that can so easily stifle active learning. As ecologists, we play the role of 'Socratic facilitators' rather than 'know-all experts' (see Feinsinger et al. 1997). To initiate and sustain local schools' programs, we organize teacher-training workshops. Local workshops are complemented by programs and materials developed at the national level (see Rozzi et al. 1998b).

A second set of activities falls under the rubric of discovery of the region's *biota and ecosystems*. These activities comprise guided visits and workshops in the various 'native' ecosystems, which include training as nature guides for the visitors to the region's national parks for park rangers, and interested schoolteachers or students, and personnel from environmental organizations. To support these activities we have prepared herbarium specimens, videos (with the national television channel), and other educational materials that can be used in park visitor centers as well in schools (see Baxter et al. 1998). For example, following a workshop on the forest birds with participation of park-rangers and ornithologists of southern Chile and Argentina in 1994, we produced as a team a field-guide that combines indigenous and scientific knowledge, recordings of the voices of the birds and brief descriptions recorded from Yamana and Mapuche people.

Other activities on re-diversifying the local environment involve local people in reflective and practical experience in achieving the biotic environment in which they wish to live. These activities include projects to plant native trees and shrubs in schoolyards and public gardens, in collaboration with local municipalities and the regional Forest Service. Also, in school yards or town squares, we ask teachers and students to reflect on the following questions and then take action: (i) how would I like my everyday environment to be? (ii) why do I desire this particular environment? (iii) how could I contribute to designing and constructing this desired environment? We also ask students to interview grandparents and other elders

(writing up the results later) about their knowledge of the natural history, uses, and care or cultivation of the plant species the students have chosen as part of their preferred environments. Following this process the students and their mentors take action to achieve those environments, by means of planting examples of the plants involved. Today, we are initiating exhaustive evaluations of these educational programs. Examples of questions we might ask ourselves are: does planting native species in urban spaces stimulate greater knowledge and valuation of the native flora? Do the native trees planted through the program provide habitat for native animal species – such as nesting sites and food for birds?

The planting program has led to creation of the Botanic Garden of Castro, Chiloé's largest town. The Garden, which includes many representative woody species of the southern Chilean forests, is located by the central square adjacent to the Museum of Modern Art, where locals also market traditional food and handicrafts (Rae et al. 1999). This location provides an appropriate setting for interactions among members of the local community, ecologists, artisans, and tourists. Besides IERCH, organizations directly involved in the project include the Municipality of Castro, the regional Forest Service office (CONAF-Castro), and specialists of the Royal Edinburgh Botanic Garden. Foresters, artists, ecologists, students, and teachers of Castro initiated the Botanic Garden in 1996; teachers plan to continue developing its educational uses (Baxter et al. 1998). Thus, the planting program integrates ecological understanding and education of children, teachers, and other citizens to transform and 'garden' their environments.

Integrating cultural and ecological values

Throughout the preceding sections we implied the existence of two contrasting environmental perspectives and the consequences of each: (1) valuing the ecological and cultural diversity of southern Chile, the perspective held by some local communities, environmentalists, and scientists; and (2) intensively homogenizing local landscapes and cultures, a perspective initiated by some Spanish colonists, followed by the governments of Chile, and maintained by most public or private development schemes of the present day. Although both perspectives can be found in southern Chile, quite obviously the second prevails. Extensive areas of forested land continue to be leased or sold outright to national and foreign enterprises or to individuals, most often for development schemes that lack even a modicum of environmental regulation (Villarroel and Torres 1996; Sabatini and Sepúlveda 1997). Government officials and environmental professionals frequently overlook the roles of colonialism and international economic pressures, instead attributing most environmental degradation to the material and intellectual poverty of local people. Furthermore, officials and professionals seldom analyze critically the entire model for Chile's national development, based almost exclusively on economic growth involving foreign markets.

Indeed, the model of economic growth is touted as the 'national' aspiration of all of Chilean society (Quiroga 1994).

Instead of acknowledging a single model for Chile's society, we emphasize the diversity of environmental attitudes and values held by ecologists, indigenous people, developers, and landowners in southern Chile (Sepúlveda and García 1997; Rozzi and Massardo 1999). This helps to distinguish between those attitudes and practices that have negative environmental effects and those whose effects are positive. The approach can both clarify the sources of environmental problems and suggest viable alternatives. Furthermore, recognizing the diversity of points of view that exists in southern Chile weakens the assumption that all stakeholders share the goal of unfettered economic growth, a conscious or unconscious assumption made by many applied ecologists throughout Latin America. Chile's economic growth over the past two decades has been described as an 'economical miracle' and presented as a model for other developing Latin American countries (Collins and Lear 1996), just as the Chilean forestry model (maintaining the nation's net area of forested landscapes but by replacing native forests with plantations of exotics) guides other nations' forestry policies even at tropical latitudes. For example, Rice et al. (1997) stated that "forest management [is] an attractive strategy because, in theory, it reconciles the economic interests of producers with the needs of conservation." Nevertheless, ecologists are increasingly realizing some of the limitations of this model. We assert that scientists retaining their objectivity can play a significant role in *political*, economic, and cultural change, well beyond promoting purely technical approaches (Rozzi et al. 1997).

Human impact on the environment is affected by the different ways in which societies understand nature and inhabit landscapes, and more broadly we have suggested that: (i) the ways we transform landscapes, (ii) our environmental ethics, (iii) our scientific conceptions and other ways we understand nature, and (iv) our cultural worldviews and social goals – are all interrelated (Rozzi 1999). The distinction we made between the two contrasting environmental perspectives on southern Chile is scarcely unique. Fifty years ago, Aldo Leopold discussed the 'land ethic' in the north-central United States: "One group (A) regards the land as soil, and its function as commodity-production; another group (B) regards the land as biota, and its function as something broader... In my own field, forestry, group A is quite content to grow trees like cabbages, with cellulose as the basic forest commodity. It feels no inhibition against violence; its ideology is agronomic. Group B, on the other hand, sees forestry as fundamentally different from agronomy because it employs natural species, and manages natural environment rather than creating an artificial one" (Leopold 1949: 258–259). Leopold's description of the ethical dichotomy in mid-century North America portrays also the contemporary dichotomy in southern Chile. As noted above, in Chile the ethic of 'Group A' is to (i) transform diverse landscapes into homogeneous ones, (ii) override the unique features of local people and biotic communities, (iii) support a linear conception of science and apply that to tight control of ecosystems, and (iv) derive inspiration from narrow economic criteria and

the concept of 'the good life' based on material consumption. The ethic of 'Group B', to which we hope IERCH belongs, is to (i) attempt to preserve a diverse mosaic of ecosystems, (ii) respect, and incorporate into planning and decisions, diverse cultural traditions and biotic communities, (iii) recognize ecological and social interactions, which add dimensions of complexity to conventional scientific understanding and bring into question the goal of tightly controlling ecosystems, and (iv) view the 'good life' as a multidimensional intersection of material, psychological, and spiritual aspects, incorporating local environments and their biota.

In summary, we propose that scientists working towards conservation in southern Chile – and elsewhere – must not only teach ecological values but also recognize those already existing in local communities, learn from those values, and support them. IERCH seeks this approach in spite of the difficulties posed by: (1) a pervasive political hostility, even within the scientific community, for projects that are not immediately profitable to the needs of the market (Rozzi and Massardo 2000); (2) the deterioration of humanistic education within scientific training – no Graduate Program in Ecology in Chilean universities includes a formal course in Philosophy of Science (see Grez et al. 1995); and (3) the lack of academic recognition of scientists involved in public outreach and solving regional environmental problems (see Bazzaz et al. 1998). At IERCH we are committed to coordinating the manifold views and practices of conservation, many of which have not been appreciated by scientists and decision-makers. We are attempting to better understand these diverse perspectives using contemporary epistemology, which allows comparisons of scientific and other forms of knowledge. In addition, a comparative environmental ethics approach allows us to examine the environmental attitudes of diverse cultures (Rozzi 1999). In southern Chile – and elsewhere – we find a fertile potential for conservation in the many people who understand and value their existences in intimate connection with the non-human living beings and diverse manifestations of the natural world.

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References

Aagesen DL (1998) On the northern fringe of the South American temperate forest. The history and conservation of the monkey-puzzle tree. Environmental History 3: 64–85

Abu Sin ME (1991) Community-based sustainable development in Central Butana, Sudan. In: Baxter PTW (ed) When the Grass is Gone, pp 152–161. The Scandinavian Institute of African Studies, Uppsala, Sweden

Aizen M and Ezcurra C (1998) High incidence of plant-animal mutualisms in the woody flora of the temperate forest of southern South America: biogeographical origin and present ecological significance. Ecología Austral 8: 217–236

Alcorn JB (1991) Ethics, economics and conservation. In: Oldfield ML and Alcorn JB (eds) Biodiversity: Culture, Conservation and Ecodevelopment, pp 317–349. Westview Press, Boulder, Colorado

Altieri MA and Masera O (1993) Sustainable rural development in Latin America: building from the bottom-up. Ecological Economics 7: 93–121

Armesto JJ and Rozzi R (1989) Seed dispersal in the rain forests of Chiloé: a survey of syndromes in comparison with other temperate and tropical forests. Journal of Biogeography 16: 219–226

Armesto JJ, Rozzi R and Willson M (1996a) Bridging scientific knowledge, education, and application in temperate ecosystems in Southern South America. Bulletin of the Ecological Society of America 77(2): 120–122

Armesto JJ, Rozzi R and León-Lobos P (1996b) Ecología de los bosques Chilenos: síntesis y proyecciones. In: Armesto JJ, Villagrán C and Kalin MT (eds) Ecología de los Bosques Nativos de Chile, pp 405–421. Editorial Universitaria, Santiago, Chile

Armesto JJ, Rozzi R, Smith-Ramírez C and Arroyo MTK (1998) Effective conservation targets in South American temperate forests. Science 282: 1271–1272

Armesto JJ, Rozzi R and Caspersen J (2000) Past, present, and future scenarios for biological diversity in South American temperate forests. In: Chapin T and Sala O (eds) Future Scenarios for Biological Diversity. Springer-Verlag, New York (in press)

Arroyo MTK, Riveros M, Penaloza A, Cavieres L and Faggi AM (1996) History and regional patterns of the cool temperate rainforest flora of Southern South America. In: Lawford RG, Alaback P, Fuentes ER (eds) High Latitude Rain Forest and Associated Ecosystems of the West Coast of the Americas: Climate, Hydrology, Ecology and Conservation, pp 134–172. Springer-Verlag, Berlin

Aylwin J (1994) Pueblos indígenas de Chile: antecedentes históricos y situación actual. Serie de Documentos No1. Instituto de Estudios Indígenas. Universidad de la Frontera, Temuco, Chile

Aylwin J (1995) Comunidades indígenas de los canales australes: antecedentes históricos y situación actual. Corporación Nacional de Desarrollo Indígena. CONADI, Temuco, Chile

Axelrod DI, Kalin-Arroyo MT and Raven PH (1991) History of temperate vegetation in the Americas. Revista Chilena de Historia Natural 64: 413–446

Baxter P, Brownless P, Fraver S, Gardner M, Maxwell S, Rae D and Rozzi R (1998) A Quest for Chilean Plants. Royal Botanic Garden Edinburgh. The Friary Press, Dorset, UK

Bazzaz F et al (1998) Ecological science and the human predicament. Science 282: 879

Bengoa J (1985) Historia del pueblo Mapuche. Ediciones SUR, Santiago, Chile

Berdichewsky IL, Saavedra A and Muenzel M (eds) (1977) Chiles Mapuche: Armee gegen Indianer. POGROM Report 25, Vienna, Austria

Berkowitz AR and Feinsinger P (1997) Fostering Environmental Literacy Through Schoolyard Ecology. Lessons from SYEFEST: Schoolyard Ecology for Elementary School Teachers. In: Adams R (ed) Environmental Education for the Next Generation, Selected Papers from the Twenty-Fifth Annual Conference of the North American Association for Environmental Education. The North American Association for Environmental Education, pp 89–92. Troy, Ohio

Cardenas R (1989) Chiloe. Diccionario de la Lengua y de la cultura. Olimpho, Santiago de Chile

Chapman A (1981) Drama and Power in a Hunting Society. Cambridge University Press, Cambridge

Claude M (1997) Una vez más la miseria. LOM Ediciones, Santiago, Chile

Collins J and Lear J (1996) Free market miracle or myth? Chile's neoliberal experiment. The Ecologist 26: 156–166

CONAF-CONAMA-BIRF (1997) Catastro y evaluación de los recursos vegetacionales nativos de Chile. CONAF, Santiago, Chile

Cooper JM (1946) The Yahgan. In: Steward JH (ed) Handbook of South American Indians, The Marginal Tribes, Vol 1, pp 81–106. Bull. 143. US Government Printing Office, Smithsonian Institution, Washington, DC

Donoso C (1993) Bosques templados de Chile y Argentina. Variación, estructura y dinámica. Editorial Universitaria, Santiago, Chile

Donoso C and Lara A (1996) Utilización de los bosques nativos en Chile: pasado, presente y futuro. In: Armesto JJ, Villagrán C and Kalin MT (eds) Ecología de los bosques nativos de Chile, pp 363–387. Editorial Universitaria, Santiago, Chile

Eser U (1998) Ecological and normative fundamentals of value-judgements in nature conservation: the case of non-indigenous plants. Advances in Human Ecology 7: 293–312

Evernden N (1992) Ecology in conservation and conversation. In: Oelschlaeger M (ed) After Earth Day: Continuing the Conservation Effort, pp 73–82. University of North Texas Press

Feinsinger P (1996) Biodiversity knowledge in Chile: diagnosis and the first prescription. TREE 11: 451–452

Feinsinger P, Margutti L and Oviedo RD (1997) School yards and nature trails: ecology education outside the university. TREE 12: 115–119

Glade A (1993) Libro rojo de los vertebrados terrestres de Chile. CONAF, Santiago, Chile

Grez AA, Jaksic FM, Moreno CA and Serey I (1995) La enseñanza de la ecología en Chile a nivel de pregrado y postgrado. Revista Chilena de Historia Natural 68: 139–152

Harttwig V (1976) Die Indianer-Agrarfrage in Chile bios 1970. Akademie Verlag, Berlin

Hedin LO, Armesto JJ and Johnson AH (1995) Patterns of nutrient loss from unpolluted, old growth temperate forests: evaluation of biogeochemical theory. Ecology 76: 493–509

Hidalgo J, Schiappacasse V, Niemeyer H, Aldunate C and Solimano I (eds) (1997) Culturas de Chile. Prehistoria: desde sus origenes hasta los albores de la conquista. Third edition, Andres Bello, Santiago, Chile

Ilg K (1982) Das Deutschtum in Chile und Argentinien. Eckartschriften Heft 83. Oesterreiche Landmanschaft. Vienna, Austria

INFOR (1997) Estadísticas forestales, Boletín Estadístico No 50. Santiago, Chile

Lara A and Villalba R (1993) A 3620-year temperate record from *Fitzroya cupressoides* rings in Southern South America. Science 260: 1104–1106

Lara A, Donoso C and Aravena JC (1996) La conservacion del bosque nativo en Chile: problemas y desafios. In: Armesto JJ, Villagrán C and Arroyo MK (eds) Ecologia de los bosques nativos de Chile, pp 335–362. Editorial Universitaria, Santiago, Chile

Leopold A (1949) A Sand County Almanac. Oxford University Press, New York

Likens GE (1991) Consequences of long-term human impacts on ecosystems. Revista Chilena de Historia Natural 64: 597–614

Lubchenco J et al (1991) The sustainable biosphere initiative: an ecological research agenda. Ecology 72: 371–412

Massardo F (1997) Plantas medicinales y medio ambiente. 2nd Congreso de Plantas Medicinales, pp 189–211. Ministerio de Salud de Chile, Santiago, Chile

Massardo F and Rozzi R (1996) Plantas medicinales chilenas: un recurso subvalorado. Ambiente y Desarrollo XII(3): 76–81

Mayorga P (1972) Costumbres y extinción de los indios del extremo austral. Arancibia Hnos, Santiago, Chile

Molina R and Correa M (1996a) Territorios y comunidades Pehuenches del Alto Bío Bío. Corporación Nacional Indígena, CONADI, Temuco, Chile

Molina R and Correa M (1996b) Territorios huilliches de Chiloé. Corporación Nacional Indígena, CONADI, Temuco, Chile

Ormazabál C (1988) Sistemas nacionales de areas silvestres protegidas en America Latina. FAO, Oficina Regional, Santiago, Chile

Pérez-Rosales V (1882) Recuerdos del pasado. Third edition (1971) Editorial Francisco de Aguirre, Santiago, Chile

Primack R, Rozzi R, Feinsinger P, Dirzo R and Massardo F (2000) Elementos de conservación biológica: perspectivas latinoamericanas. Fondo de Cultura Económica, Ciudad de México, México (in press)

Princen T and Finger M (1994) Environmental NGOs in World Politics: Linking the Local and the Global. Routledge, New York

Quiroga R (ed) (1994) El tigre sin selva. Instituto de Ecología Política, Santiago, Chile

Rae D, Massardo F, Gardner M, Rozzi R, Baxter P, Armesto J, Newton A and Cavieres L (1999) Los jardines botánicos y la valoración de la flora de los bosques nativos de Chile: una colaboración entre el Jardín Botánico de Edimburgo y el Instituto de Investigaciones Ecológicas Chiloé. Ambiente y Desarrollo XV(3): 60–70

Rice RE, Gullison RE and Reid JW (1997) Can sustainable management saves tropical forests? Scientific American (April 1997) 276: 44–49

Rozzi R (1997) Hacia una superación de la dicotomíaantropocentrismo/biocentrismo. Ambiente y Desarrollo XIII(3): 48–58

Rozzi R (1999) The reciprocal links between evolutionary-ecological sciences and environmental ethics. BioScience 49(11): 911–921

Rozzi R and Armesto JJ (1996) Hacia una ecología sintética: la propuesta del Instituto de Investigaciones Ecológicas Chiloé. Ambiente y Desarrollo XII(1): 76–81

Rozzi R and Massardo F (1999) Relaciones recíprocas entre las ciencias y la ética ambiental para la conservacion. Persona y Sociedad XIII(1): 41–52

Rozzi R and Massardo F (2000) Implicancias ecologicas y sociales de la bioingenieria: un analisis desde el sur de Latinoamerica. In: Kwiatkowska T and Issa J (eds) Ingenieria Genetica y Ambiental: Problemas Filosoficos y Sociales. Editorial Plaza y Valdes, Mexico (in press)

Rozzi R and Torres-Mura JC (1990) El chungungo *Lutra felina* al sur de la Isla Grande de Chiloé: Antecedentes para su conservación. Medio Ambiente 11: 24–28

Rozzi R, Armesto JJ and Figueroa J (1994) Biodiversidad y conservación de los bosques nativos de Chile: una aproximación jerárquica. Bosque 15: 55–64

Rozzi R, Martínez D, Willson MF and Sabag C (1996) Avifauna de los bosques templados de Sudamérica. In: Armesto JJ, Villagrán C and Kalin MT (eds) Ecología de los bosques nativos de Chile, pp 135–152. Editorial Universitaria, Santiago, Chile

Rozzi R, Armesto JJ, Pickett STA, Lehmann S and Massardo F (1997) Recuperando el vínculo entre la ciencia y la ética: una aproximación ecológica. In: Montenegro G and Timmermann B (eds) Aspectos ambientales, ideológicos, eticos y políticos en el debate de bioprospección de recursos genéticos en Chile, vol 5, pp 71–75. Noticiero de la Sociedad de Biología de Chile

Rozzi R, Hargrove E, Armesto JJ, Pickett STA and Silander J (1998a) 'Natural drift' as a post-modern metaphor. Revista Chilena de Historia Natural 71: 9–21

Rozzi R, Feinsinger P and Riveros R (1998b) La enseñanza de la ecología en el entorno cotidiano. Second edition, Ministerio de Educación de Chile, Santiago, Chile

Sabatini F and Sepúlveda C (eds) (1997) Conflictos ambientales. Entre la globalización y la sociedad civil. CIPMA, Santiago, Chile

Schmalz I (1970) Dokumente zur Geschichte der Deutschen Einwanderung. Heft I: Carl Alexander Simon. Berlin

Schmalz I (1971) Dokumente zur Geschichte der Deutschen Einwanderung. Heft II: Adolf Langer, Alfred Buck, Richard Brellenthin & Jakob Pfeiffer. Berlin

Schmalz I (1972) Dokumente zur Geschichte der Deutschen Einwanderung. Heft III: Klara Anwandter, Theodor Koerner & Sigfried Froelich. Berlin

Sepúlveda C and García D (1997) Biodiversidad (II): Cooperación público-privada como estrategia para la conservación de la biodiversidad en Chile. Ambiente y Desarrollo XIII(2): 35–45

Shaxson TF (1991) National development policy and soil conservation programs. In: Conservation for Sustainable Hillslope Farming, International Workshop Proceedings, FAO, Masera, Lesotho

Simonetti J, Kalin-Arroyo MT, Spotorno AE and Losada E (eds) (1996) Diversidad biológica de Chile. Conicyt, Santiago, Chile

Soto D and Campos H (1996) Los lagos oligotróficos del bosque templado húmedo del sur de Chile. In: Armesto JJ, Villagrán C and Kalin MT (eds) Ecología de los bosques nativos de Chile, pp 317–334. Editorial Universitaria, Santiago, Chile

Stevens S (1997) Conservation through Cultural Survival: Indigenous Peoples and Protected Areas. Island Press, California

Toulmin C (1991) Bridging the gap between top-down and bottom-up in natural resource management. In: Baxter PTW (ed) When the Grass is Gone, pp 152–161. The Scandinavian Institute of African Studies, Uppsala, Sweden

Veblen TT and Schlegel FM (1982) Reseña ecológica de los bosques del sur de Chile. Bosque 2: 73–115

Villagrán C and Hinojosa F (1997) Historia de los bosques del sur de Sudamérica II: análisis fitogeográfico. Revista Chilena de Historia Natural 70: 241–267

Villarroel P and Torres V (1996) Conama dio 'luz verde condicionada' a proyecto forestal Río Cóndor. Ambiente y Desarrollo XII(4): 6–19

Vitousek PM (1994) Beyond global warming: ecology and global change. Ecology 75: 1861–1876

Willson MF (1991) Seed dispersal by frugivorous animals in temperate forests. Revista Chilena de Historia Natural 64: 537–554

Willson MF and Armesto JJ (1996) The natural history of Chiloé: on Darwin's trail. Revista Chilena de Historia Natural 69: 149–161

Willson MF, De Santo T, Sabag C and Armesto JJ (1994) Avian communities of fragmented south-temperate rain forests in Chile. Conservation Biology 8: 508–520

Willson MF, Smith-Ramírez C, Sabag C and Hernández JF (1996) Mutualismos entre plantas y animales en bosques templados de Chile. In: Armesto JJ, Villagrán C and Kalin MT (eds) Ecología de los bosques nativos de Chile, pp 251–264. Editorial Universitaria, Santiago, Chile

Wilcox K (1995) Chile's Native Forests: A Conservation Legacy. Ancient Forest International, Redway, California