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Conservation strategies for biodiversity and indigenous people in Chilean forest ecosystems

J. J. Armesto^{*†}, C. Smith-Ramírez^{*}, R. Rozzi[‡]

The distribution of Chilean temperate forests has been greatly disrupted by human activities, mainly through logging, land clearing for agriculture, and replacement of native forests by extensive commercial plantations of exotic trees. More than ½ million people of indigenous ancestry (mainly Pehuenche and Huilliche) still live in close association with forests in south-central Chile. Indigenous people have been forced to retreat, along with the last remains of native forests, towards marginal lands, characterised by low productivity and limited accessibility. This process has been driven by a historical trend that reassigned public and indigenous land to private or industrial landowners, and by a Chilean forestry policy that has ignored biodiversity and non-timber forest products, and undervalued native forests by providing costly subsidies to industrial plantations for timber and pulp production. As a result of these policies, two major conflicts have emerged: indigenous people encroached by timber plantations are resisting the expansion of commercial forestry, and the conservation of the last remains of biologically valuable habitat is at odds with land use claims by indigenous groups in less accessible areas. A promising solution to these problems is the development of mixed use landscapes or “extractive reserves”, where non-degrading economic uses of forests, such as ecotourism and harvesting of non-timber products, coexist with the provision of ecosystem services and protection of biodiversity within indigenous land. Regulation of land use in extractive reserves requires strengthening traditional knowledge of natural resource use and government incentives to manage and conserve native forests.

Keywords extractive reserves biodiversity land use, exotic plantations ecotourism

INTRODUCTION

One of the major challenges for conservation biology today is to enhance the level of protection of biological diversity in landscapes increasingly dominated by humans (Vitousek et al 1997, Armesto et al 1998, Bruner et al 2001). In most countries, conservation of biodiversity relies strongly on a system of national parks and reserves, often established in marginal land, usually far from major urban and production centres. This strategy has worked best in developed nations, where land can be allocated to different uses on a more permanent

^{*}Laboratorio de Ecología de Bosques, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile, and Fundación “Senda Darwin”, Ancud, Chiloe, Chile

[†]Author for correspondence: J. J. Armesto, Facultad de Ciencias, Universidad de Chile, Casilla 653, Santiago, Chile. email: jarmesto@uchile.cl

[‡]Department of Ecology and Evolutionary Biology, University of Connecticut, 75 North Eagleville Rd., Storrs, CT 06269–3043, USA

basis and human rural population has either levelled off or declined over the past decades. To satisfy the internal demand for natural resources, these countries depend on intensive agriculture and forestry and on the import of materials from third world nations, thus relieving the pressure on their own natural ecosystems. In contrast, conflicts often arise in developing countries because of the large proportion of the population still living in rural areas and because a large proportion of their income derives from the exploitation of natural resources to supply internal and foreign markets. Economic pressures to expand human-used areas beyond their present limits, defined by accessibility and remoteness, will come into direct conflict with conservation goals seeking to increase, or even stabilise, the proportion of land currently protected (Musters et al. 2000; Liu et al. 2001).

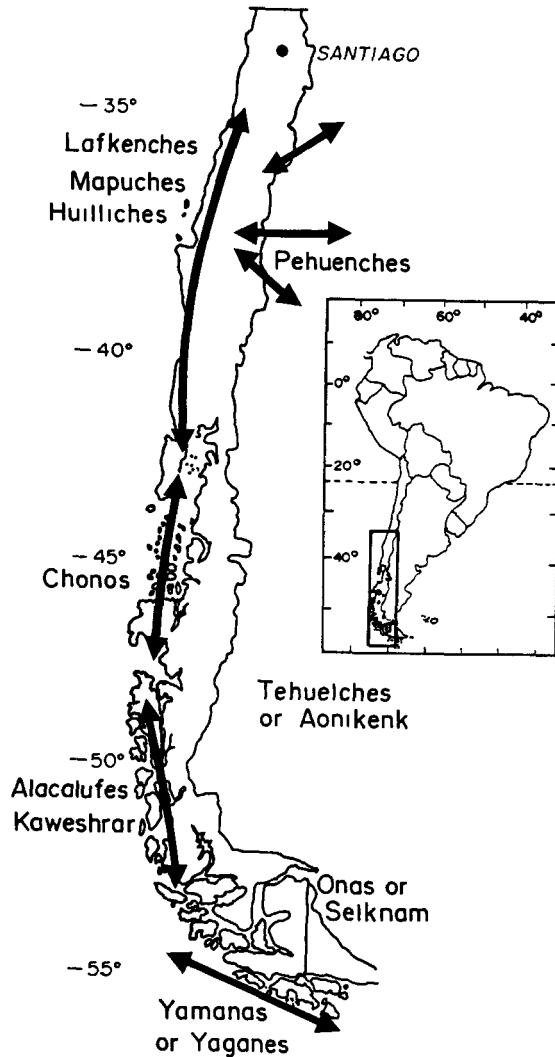
Among the most serious conflicts that occur in or around wildlife reserves are those involving indigenous people. Problems have originated from government policies that allocate land to biological reserves without taking into account the current interests and activities of local residents (Musters et al. 2000), or from long-standing disputes over land tenure rights (Noble & Dirzo 1997). Forests are frequently the focus of dissension because of their importance in providing commodities and services to local people, which must be reconciled with their function as reservoirs of biodiversity and major regulators of hydrologic and carbon cycles on both regional and global scales (Schulze et al. 2000). In many developing nations, free-market economic policies have stimulated the transfer of public land to large international holdings seeking the rapid exploitation of timber resources, often with little regard for the cultural and subsistence value of native forests for indigenous people, or for the sustainability of logging operations (Lara & Veblen 1993; Marchak 1995; Noble & Dirzo 1997). At the same time, local communities are left adrift confronted with forestry practices that operate within large, private land holdings, which are based on massive monocultures of rapidly growing tree species managed for a single commercial product (e.g., chemical pulp, sawn wood). These land-use practices entail radical changes to the original landscape mosaic, including reduction of native vegetation cover and diversity, degradation of ecosystems (soil erosion, contamination), and the loss of a wide range of natural resources traditionally valued by local communities (Marchak 1995; Claude 1997).

The history of exploitation, management, and conservation of Chilean forests (Armesto et al. 1994; Donoso & Lara 1996) follows closely the series of events described above and, therefore, can serve as an example of the type of problems being faced by conservation biologists in developing countries with a free-market economy. As discussed below, forestry policies in Chile have led to the intensification of social conflicts over land tenure rights and, over the past decades, have had a direct effect on the conservation of biodiversity and social development (Claude 1997; Armesto et al. 1998). In this paper, we review the strategies for conservation and management of the temperate forests of southern Chile with regard to the nature of conflicts involving policy and local communities, particularly indigenous people. We propose ways in which such conflicts can be alleviated, with the aim of favouring the wellbeing of local communities, the prospects for conservation of forest habitat, and the sustainable use of economic resources provided by biological diversity.

INDIGENOUS COMMUNITIES IN SOUTH-CENTRAL CHILE

At the time of European colonisation, the temperate region of Chile was occupied by at least eight major ethnic groups (Fig. 1), with an estimated population totalling more than 1 million. Due to the spread of pests and disease following European settlement, as well as the direct slaughter of indigenous people by these conquerors, many of these aboriginal cultures are now extinct, or have been reduced to a small number of remnant populations (Bengoa, 1987; Grebe 1998). Some ethnic groups from the extreme south, the Chono, the Ona, and the

Fig. 1 Indigenous populations historically occupying territories in the temperate forest region of Chile (35–55°S) Mapuche is general name for several extant ethnic groups that include Pehuenche, Lafkenche, and Huilliche



Tehuelche, became completely extinct, while the Alacaluf and Yahgan maintain their language and a rich traditional ecological knowledge, in spite of their very small population (less than 100 people) in the Magellan region (R Rozzi unpubl data). Among the Mapuche groups, the Picunche became rapidly extinct after the first contact with Spaniards in central Chile, but the Lafkenche, Pehuenche, and Huilliche still maintain significant populations in the IX and X administrative regions of southern Chile (39–42°S, Fig. 1). Approximately ½ million Mapuche (including Lafkenche, Pehuenche, and Huilliche) people live in very marginal conditions in large urban centres (mainly Santiago), but another ½ million still reside in the temperate forest region of south-central Chile, mainly in rural areas, maintaining their original culture and social practices (Grebe 1998). In the range of southern temperate forests, the Pehuenche and Huilliche are the main holders of large expanses of forest land, yet their land tenure rights are not always clear (see below). Pehuenche settlements historically occupied the northern range of the temperate forest and were associated with forests dominated by *Araucaria araucana* (monkey-puzzle) and *Nothofagus obliqua* (roble). Pehuenche are now

confined largely to both sides of the Andes between 38 and 39°S (Fig. 1). Important Pehuenche communities in Chile are found in the upper Bío-Bío valley and around the Lonquimay volcano (Molina & Correa 1996a). Huilliche settlements presently occupy significant territories within the range of evergreen temperate rain forests in the Valdivian ecoregion, primarily along the coast between the River Bueno (40°S) and south-central Chiloé Island (42°50'S), but also in some Andean sectors around Lago Ranco in the Lake District, 39–41°S (Molina & Correa 1996b, 1998). In the coastal range of Osorno and south-central Chiloé Island, Huilliche land includes areas covered by other important forest types in addition to Valdivian forests, such as North Patagonian rain forest, with a mixed canopy dominated by *Nothofagus nitida* (southern beech) and *Podocarpus nubigena* (mañío), and upper montane *Fitzroya cupressoides* (alerce) forests (Armesto et al. 1995), of which alerce is considered an endangered tree species (Gardner et al. 1999). In southern Chiloé Island, Huilliche territories include extensive lowland conifer forests dominated by *Pilgerodendron uviferum* (cypress) and *Tepualia stipularis* (tepu).

Indigenous people in these communities make use of a wide range of natural products from native forests, which sustain a modest subsistence economy. Among the main resources used by native people are wooden posts, vegetable dyes, firewood, berries, plant material for baskets and brooms, and edible fungi (Table 1) (Smith-Ramírez 1996). The diversity of non-timber forest products used by Pehuenche and Huilliche groups is rooted in their deep knowledge of forest wildlife and the resources they provide; a cumulative traditional knowledge that has been well documented in recent ethnobotanic studies (Aldunate & Villagrán 1991; Villagrán 1998; Tacón 1999; Catalán 2000). The appreciation of the value of the native flora is illustrated by the fact that between 78 and 95% of the local plants have known uses for the resident Pehuenche and Huilliche in southern Chile (Villagrán et al. 1983; Aldunate & Villagrán 1991; Meza & Villagrán 1991; Smith-Ramírez 1996; Catalán 2000). Field studies have documented the long history of association between indigenous people and forests in southern Chile. Traditional knowledge reveals a much broader perception of forest resources (Table 1) than is presently recognised by forest managers. This cultural background has important implications for the development of alternative practices for managing native forests, as they promote a philosophy that respects the value of biodiversity and view forests as providers of multiple resources. Such views are currently much needed in Chile.

TWO EXAMPLES OF INDIGENOUS USE OF FOREST RESOURCES

Alerce timber in the coastal range of Osorno

Logging “green” alerce trees (*Fitzroya cupressoides*, Cupressaceae) is presently illegal in Chile, because the Chilean Government declared every living tree a “Natural Monument” in 1977 (Gardner et al. 1999). However, the history of logging this extremely long-lived conifer dates back to the late 16th century, extending to the less accessible areas in the Lake District after the railway was built in southern Chile and mobile sawmills were introduced in the late 1800s (Molina et al. unpubl. data). Thousands of hectares of alerce forests were extirpated from the central depression of the Lake District (39–41°S) during this period and populations of alerce in the Andes and coastal range were severely reduced until the Government imposed a ban on its harvest in the late 1970s (Veblen et al. 1976). However, some illegal exploitations are still reported.

Alerce timber has a high market value because of its remarkable resistance to decay; the main products are posts and shingles for buildings. Before the arrival of Spaniards, alerce timber was not used by the native Americans. However, in the 16th and 17th centuries, Huilliche were used as the labour force in the exploitation of alerce timber by the Spaniards,

in a form of slavery. After the colonial period, free Huilliche families continued to harvest alerce timber using traditional methods. Some stands of alerce on the coast of Osorno (40°S) have been harvested by Huilliche communities for more than a century for the production of shingles and roundwood. During the 1950s and 1960s other stands in the same area were subjected to industrial exploitation using portable sawmills for production of shingles, sawn wood, and posts. A number of alerce stands ($n = 12$) that were used solely by local Huilliche were compared with stands subjected to industrial use ($n = 10$) prior to 1970, to assess the relative effects of non-industrial and industrial exploitation on the subsequent regeneration of alerce (C. Smith-Ramírez & E. Rivera unpubl. data). Regeneration (number of saplings) of *Fitzroya* in alerce stands harvested by Huilliche was twice as abundant as in stands that were exploited industrially. A higher number of green trees (>2 m tall) that served as seed sources remained standing in the areas historically harvested by Huilliche. Areas subjected to industrial exploitation had a greater number of stumps per unit area, reflecting a more intensive, short-term extraction. Logging of alerce by Huilliche communities followed traditional practices (Molina et al. unpubl. data) that appear to have less effect on the regeneration of the resource because Huilliches take a smaller proportion of living trees and do not use firewood for the operation of mills, which accounts for the loss of many young alerce trees in industrial operations. In contrast, industrial logging was aimed at maximising harvest and short term gain, thereby greatly reducing the regeneration potential of alerce (Veblen & Ashton 1982). Industrial exploitation and European settlement were largely responsible for the demise of alerce from the Lake District of southern Chile (Veblen et al. 1976) and the lack of regeneration in clearcut areas of the Andes (Donoso & Lara 1996). Because of this large-scale exploitation, harvesting of green alerce trees is now banned, which makes this potentially renewable resource no longer accessible to local communities.

Table 1 Non-timber resources traditionally derived from native forests by local communities in south central Chile. Based on sources cited in Smith-Ramírez (1996) and unpublished data.

Latitude	Locality or community	Plant group or taxa	Product or use	Number of species used
Data for specific localities				
37°30'S	Alto de Bio Bio	Fungi	Food	10
40°30'S	San Juan de la Costa	Fungi	Food	15
		Woody vines	Baskets and brooms	5
42°S	Chiloe Island	Woody vines	Baskets	4
42°30'S	Alao Island	Trees and shrubs	Natural dyes	9
42°30'S	Quinchao Island	Trees and shrubs	Natural dyes	18
Regional data				
39–42°S		All vascular plants	Medicinal	104
39–42°S		Fleshy fruited trees and shrubs	Food	8(>17)*
39–42°S		Trees	Woodcrafts	>40

*Number of fruit species that are traded in local markets. In parentheses total number of species with fleshy fruits known to be consumed by people.

Traditional use of voqui-pilfuco, *Berberidopsis corallina*

Berberidopsis corallina (Berberidopsidaceae) is a monotypic endemic climber with very scattered populations and a relatively narrow distribution range associated exclusively with the coastal forests of south-central Chile (37–41°S) (Villagrán 1995). Because of the massive destruction of its habitat, populations of this species have become very rare in the wild. The species is now listed as endangered, which has stimulated important efforts for *ex situ* conservation (Gardner 1997). Huilliche families from San Juan de la Costa, in the coastal range of Osorno, have traditionally harvested the long, etiolated stems of *Berberidopsis* for making handsome trays and baskets that are sold at local craft markets (Smith-Ramírez 1996). Because of the fine quality of the material, these baskets are highly valued and sold in some foreign markets as well.

Although quantitative assessments of the effects of indigenous exploitation of *Berberidopsis* are lacking, observations suggest that the use of the plant by Huilliche families is not degrading the resource (C. Smith-Ramírez pers. obs.). Collectors harvest the long woody stems of *Berberidopsis* at least 10 cm above the ground, thus allowing the plant to grow back from root stocks. Normally, regenerating stems become woody and can be harvested again in 3–5 years. According to our field observations, traditional harvesting of *Berberidopsis* by local families may act as a pruning method, thus stimulating vegetative growth. Vegetative growth is less frequent in areas where traditional harvesting has not been practiced (C. Smith-Ramírez pers. obs.). In any case, the long-term survival of *Berberidopsis* in its local habitat does not seem to be threatened by traditional harvesting, but rather by the large-scale loss of forest habitat. Consequently, the conservation of this endangered plant will depend on the preservation of the native forest remnants where this species can be found. Currently, the occurrence of this rare climber is negatively affected by felling and burning of remaining native forests, and by the expansion of commercial plantations of exotic trees, such as *Pinus radiata*, *Pseudotsuga menziesii*, and *Eucalyptus* spp. in coastal areas of south-central Chile. Survival of *Berberidopsis* plants within the exotic plantations is difficult and the growing vines become fragile and unsuitable for weaving baskets (C. Smith-Ramírez unpubl. data). In addition, native pollinators and dispersers of *Berberidopsis* do not occur in plantation forests. Sustainable harvesting of *Berberidopsis* for crafting purposes can be enhanced by forest policies that support the preservation of native forest fragments containing populations of this species around local communities.

CHILEAN FOREST POLICY AND CONFLICTS OVER LAND USE

The above discussion sets the stage for analysis of the major sources of social conflict over alternative forms of land management in the temperate region of southern Chile. One of the oldest sources of conflict dates back to the historical assignment of territories to Pehuenches and Huilliches by the Chilean Republic, following independence from Spain in the early 19th century. In many cases these assignments did not respect original agreements reached between native people and the Spanish Crown in the colonial period (Molina & Correa 1996a, 1996b; Vergara et al. 1996). The history of land tenure by indigenous people can be summarised as a gradual process of seizure of their land by the Chilean Government and by private investors. As the value of land and its natural resources became more attractive to private investors and new access routes opened during the late 1800s and early 1900s the disputes over land tenure became more severe. Molina & Correa (1996a, 1996b, 1998) documented, with abundant historical records, the legal frauds committed by individuals and the Chilean Government to seize, or purchase at very low price, land ancestrally occupied by Huilliche and Pehuenche. The lack of social organisation, marginal condition, and decline of the rural indigenous population in the first half of the 20th century facilitated this pattern of

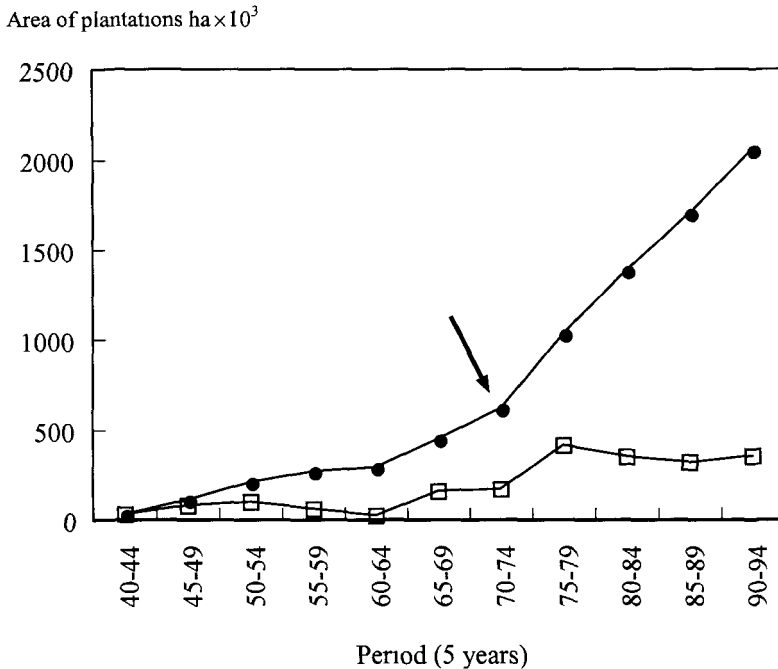


Fig. 2 The expansion of industrial plantations of exotic trees (mainly *Pinus radiata* and *Eucalyptus* spp.) in Chile since 1940. Starting in 1974 (marked by the arrow), a government subsidy was provided to landowners to defer costs of planting and managing plantations. Plantations have extended mainly along the coast between 37 and 40°S. Filled circles: cumulative area of plantations. Open circles: amount of land planted in each 5 year interval. Data from Instituto Forestal, Chile (1995).

abuse. In the late 1800s, the Chilean Government promoted the transfer of indigenous territories in the Chilean Lake District (38–41°S) to European immigrants (Vergara et al 1996), who settled the area and developed a prosperous agricultural and industrial economy responsible for much loss of forest cover.

Because of this historical context, the confrontation between indigenous people and private land-holders in south-central Chile has persisted until today (Molina & Correa 1996a, 1996b, 1998). These conflicts have escalated at times into regional disputes, when several families or indigenous groups have allied to defend their rights on the land. As indigenous people were forced away from the most valuable and productive land into less accessible areas of lower productivity, their subsistence economy has worsened, often leading to mismanagement, resulting in overgrazing and intense soil erosion (Aravena 1995).

The same trend described for indigenous territories has been experienced by the original cover of native forests, particularly in their northern range (37–40°S). The expansion of the agricultural frontier in the 19th and 20th centuries and, more recently, the massive growth of industrial plantations (Fig. 2) have greatly reduced the cover of native forests, which became restricted to the less productive environments, largely above 600 m elevation in the Coastal and Andean ranges. The expansion of commercial plantations of exotic trees was promoted by a national forest policy that subsidised the cost of site preparation, planting, and thinning (Lara & Veblen 1993). Between 1974 and 1994 nearly 2 million hectares of *Pinus radiata* were planted between 36 and 39°S, which is the same latitudinal range where the floristically richest forests in south-central Chile were found (Armesto et al 1998). Supported by

government subsidies, the timber industry in Chile changed rapidly during this period, from a small-scale operation, based on mobile sawmills and selective logging of native forest stands, to an industrial business based largely on commercial plantations of fast-growing timber trees (Donoso & Lara 1996; Claude 1997). Today, timber exports from tree plantations represent nearly 10% of the gross national income (Claude 1997). It must be noted, however, that the economic success of forestry in Chile is derived primarily from government subsidies, still in place, that reduced production costs and, secondly, from the historical transfer of large public land holdings and indigenous territories to private investors at prices well below market values. In our opinion, these government policies are largely responsible for the present situation, where native forests are seriously undervalued with respect to subsidised plantations for pulp and timber products (Donoso & Lara 1996; Catalán & Ramos 1999). The expansion of plantation forestry, based almost entirely on exotic species, has also had major social effects. It has forced small and poor landowners to sell their land and move to cities, with a loss of quality of life (Lara & Veblen 1993; Donoso & Lara 1996; Catalán & Ramos 1999). In addition, disputes over land rights between private forestry companies and indigenous communities, still dependent on natural resources for their subsistence, have intensified over time. The large-scale homogenisation of the landscape in south-central Chile has generated a cultural and social crisis for native Americans (Catalán & Ramos 1999). The battle has escalated in the last two decades, involving the timber industry and Pehuenche communities in the highlands of the Bío-Bío valley and indigenous settlements in the vicinity of Temuco (39°S), indicating that the situation for indigenous people has not improved.

CHILEAN FOREST POLICY EFFECTS ON BIODIVERSITY AND INDIGENOUS COMMUNITIES

As a consequence of the historical trends discussed above, native forest cover has been greatly reduced and fragmented over the past 50 years. Forests have been converted to farmland or pasture, even in low productivity areas, a process which is often followed by erosion and further decline in productivity (Fig. 3). This land-use pattern has become predominant in south-central Chile. The most extensive areas of timber plantations coincide with areas characterised by a high endemism and species richness of native trees and vertebrates (Armesto et al. 1998). Because Pleistocene glaciation had large and devastating effects in the extreme south and the Andean highlands, most biological diversity in Chilean forests was historically concentrated in coastal and lowland areas at mid latitudes (37–40°S) that were less affected by the expansion of mountain glaciers. This latitudinal range is at the heart of the modern pine industry (Fig. 2). Consequently, many tree species and native forest types in this region are rapidly declining (Donoso & Lara 1996; Bustamante & Castor 1998). Examples of endangered ecosystems in this region include olivillo (*Aextoxicon punctatum*) forests (32–42°S) and ruil (*Nothofagus alessandrii*) forest (confined to 37°S). Examples of endangered tree species (Benoit 1989) in coastal ecosystems include *Nothofagus glauca*, *N. alessandrii* (both Nothofagaceae), *Gomortega keule* (in the monotypic family Gomortegaceae), and *Pitavia punctata* (Rutaceae).

Although these land-use trends have been most evident in Pehuenche territories during recent decades, the expansion of plantation forestry and land conversion is reaching the Huilliche territories (40–42°S) and forests located in less accessible areas further south (Catalán & Ramos 1999). The urgent need to preserve biological diversity in native forests remaining in these southern locations (see Myers et al. 2000) may become yet another source of conflict with the legitimate rights of indigenous communities over the land. Such conflicts have already emerged in Chiloé National Park (42°30'S), in the western coast of Chiloé Island (Fig. 1), where land claimed by Huilliche families was incorporated into the national

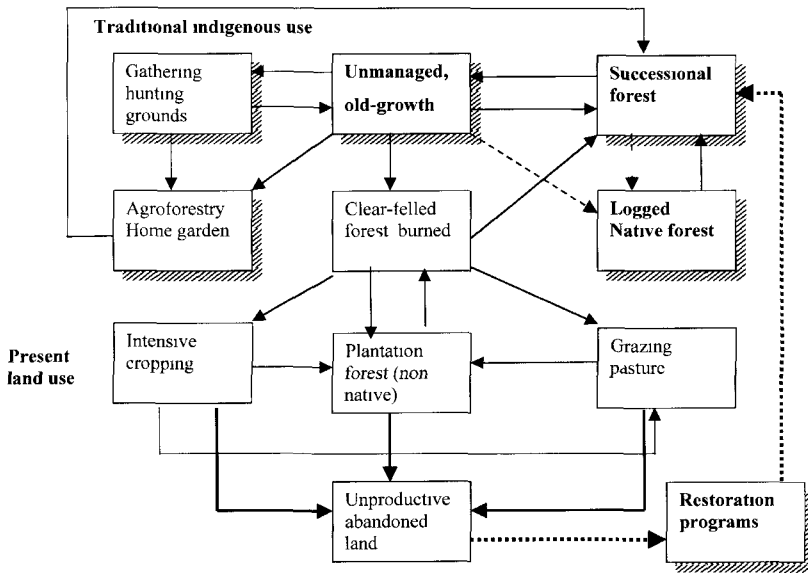


Fig. 3 Cover changes associated with land use in south-central Chile. Boxes indicate land condition and arrows indicate the most common transitions between states. Transformation and degradation of the original forest structure and composition increases from top to bottom of the diagram. Return times from each state to the original old-growth forest and likelihood of restoring the original structure and composition increase and decrease, respectively, from top to bottom. Land value for conservation of biodiversity decreases from top to bottom. Major investments may be necessary to restore forests in land abandoned due to loss of fertility. Land uses shown in shaded boxes are more compatible with the conservation of biodiversity and ecosystem services.

park, created in 1985. Negotiations with the Chilean Government will allow the Huilliches to regain some forest land originally included within the park boundary, for uses that have not been well established. Moreover, if the present forest policy with its subsidy to industrial plantations continues to drive land use trends, there will be strong pressure for further conversion of native forests to other land uses, primarily pastures and exotic tree plantations (Fig. 3). Although these options provide a short-term source of income for local communities, they have negative long-term social effects and accelerate the loss of biodiversity and other ecosystem services in the Valdivian forest ecoregion (Fig. 3). Clearly, what is needed is the design of alternative land-use options that are both economically and socially feasible (Catalán 2000, Musters et al. 2000), thus helping indigenous people to conserve their culture and their forests.

TOP-DOWN VERSUS BOTTOM-UP INFLUENCES ON DEVELOPMENT

Conservation programmes in the Southern Hemisphere have frequently failed simply because professionals from outside the region come to teach local people and institutions how to solve their problems using models developed elsewhere. Forest policies generally originate as top-down approaches, with little input from the local communities that should benefit from these programmes. In Chile, the current forest policy, although successful in generating an income from commercial plantations, has negative side effects both socially and ecologically (Claude 1997). These effects include the breakdown of many rural communities, the disruption of

local subsistence economies, and the loss of biological diversity (Lara & Veblen 1993; Catalán & Ramos 1999). Subsidies to plantations have resulted in large-scale homogenisation of the countryside, especially between 37 and 40°S, with concomitant declines in the populations of several endemic tree species and an increase in the number of ethnic conflicts. Ethnic disputes originate largely because indigenous communities have claims on the land occupied by forestry companies and because, as a result of the spread of exotic tree plantations, natural resources and ecosystem services associated with native forests have been lost from vast rural areas. Bottom-up approaches, based on understanding the needs and capacities of local communities, combined with novel top-down initiatives, such as government incentives for the sustainable use of native forests, can change the current land-use trends illustrated in Fig. 3. New land-use options should favour local economies and stimulate forest management practices that do not imply large losses of biodiversity and degradation of the natural resource base.

“EXTRACTIVE RESERVES” OPEN TO TOURISM: A DEVELOPMENT OPTION FOR INDIGENOUS LAND

The basis for this proposal is the premise that land should be allocated to multiple uses, including among them the supply of valuable commodities and services to benefit the land holder and the local community, and the protection of land, water, and habitats for biological diversity, wherever possible. The proposal for extractive reserves derives from an idea implemented in some tropical countries, and originated as a combination of a bottom-up approach from local communities living in extremely marginal conditions in the Amazonia (Nepstad & Schwartzman 1992) and government policies to support local development. The purposes of extractive reserves are not fixed but can be defined by each local community based on their economic and biological potential.

Proposed goals of extractive reserves may vary in different areas of south-central Chile, depending on the productivity of the land and prospects for development set forth by local communities. An example of such a proposal for 18 Mapuche communities in the region of Temuco (39°S) has been recently developed by Catalán (2000). The maintenance of native forest fragments around settlements would allow for the continuation of low-level harvesting and gathering activities (Fig. 3), which may offset shifts towards more intensive, plantation-based silviculture or extensive agricultural systems in other portions of the landscape. In addition, extractive reserves may provide income to local communities through government subsidies allocated to sustainable forest management, certification of forest products for international markets, revenues for sequestration of carbon dioxide, and other ecosystem services, thus enhancing the economic value of native forest cover. Education and ecotourism projects supported by non-government or government agencies could take advantage of a less degraded landscape within extractive reserves, thus allowing for the development of a multiple-use land mosaic.

Tourism can be a major source of income for organised indigenous communities in southern Chile, as suggested by figures from other temperate and tropical forest regions. Pimentel et al. (1997) considered ecotourism to be one of the most important economic benefits derived from biodiversity for local communities. Ecotourism is the second most important industry in Costa Rica, where it generates an income of more than US\$500 million annually. The Chilean tourism industry is still poorly developed, yet this economic activity has grown an annual average of 15% during the last decade (Smith-Ramírez 1999). For the temperate forest region alone the gross income from tourism has increased 2–3% per year. Sports fishing, a tourist activity closely associated with undisturbed forested catchments, generates annual incomes of US\$800 million in New Zealand, US\$460 million in Canada,

and US\$100 million in Bariloche, a province of Argentina in southern South America. In contrast, revenues from sports fishing for the entire country of Chile is estimated at under US\$1 million (Smith-Ramírez 1999). Certainly, there is much room for improvement of this figure, particularly because of the growing interest of tourists worldwide in visiting southern Chile. Figures for the number of jobs generated directly by tourism are 100 times higher than those generated by the woodchip industry and 15 times higher than jobs provided by commercial forestry (Claude 1997). Extractive reserves open to tourism in indigenous land can provide extra income to local communities, to complement other economic benefits derived from gathering and low-level harvesting. Self-imposed regulations, defined inside the local community as a bottom-up policy development, should prevent the degradation of resources and ecosystems, in the same way as it has been traditionally accomplished by indigenous people. Such policies will be derived from strengthening local knowledge about forest resources and traditional management practices (see, e.g., Tacón 1999, Catalán 2000). Marketing of products of extractive reserves should be regulated so that added values benefit the local communities more than intermediaries.

CONCLUDING REMARKS

We propose that solutions to the conflicts between conservation goals and indigenous communities can be found in the combination of both bottom-up (community-based initiatives) and top-down (government incentives) approaches to land management, rather than in the strongly top-down policies that prevail in most developing countries such as Chile. Bottom-up initiatives should also be facilitated through community-based education and training programmes, aimed at increasing the capacity of local communities to define and implement their own management goals for using and conserving regional ecosystems. Strengthening traditional knowledge of local cultures about the values and uses of biodiversity should be a priority, as much of this knowledge is rapidly being lost as landscapes and local communities are transformed by land use (Catalán & Ramos 1999). The implementation of extractive reserves, open to tourism, can provide a broad range of opportunities for local communities to define and achieve their own development goals. The maintenance of heterogeneous landscape mosaics within extractive reserves, rather than the homogenisation of land cover (e.g., plantations), is compatible with the need to conserve regional biodiversity and essential ecosystem services. This kind of initiative should be facilitated by re-oriented government subsidies aimed at favouring sustainable, multipurpose forestry and biodiversity-friendly land-use options. Such strategies, at a regional scale, can provide alternatives for preserving biodiversity in biologically rich and, at the same time, economically valuable land, which for the most part is unlikely to be set aside for protection because of present social needs.

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