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Mapuche perceptions and conservation of Andean *Nothofagus* forests and their medicinal plants: a case study from a rural community in Patagonia, Argentina

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Abstract In a Mapuche community situated in the sub-antarctic forest of the northwest of Argentine Patagonia, analysis was carried out on forest environmental perception and its relation to the resilience of the body of traditional botanical knowledge regarding medicinal plants. Data was obtained on the ethno-classification and differential use of the forest gathering environment with respect to its practical and cultural value. Semi-structured interviews were carried out with 30 randomly chosen inhabitants, and the data were analysed using qualitative methods and non-parametric statistics. Most citations (64.5%) were of species gathered in *Nothofagus antarctica* forest, 26.2% were of species from *N. pumilio* forest, and 20.3% referred to species from a mixed forest, with *N. dombeyi*. The forests studied have low values for similarity in terms of medicinal species richness, indicating a unique offer of therapeutic resources in each one. The use of the different forest types seems to be associated with the search for therapeutic resources for specific ailments. However, the redundancy of functions of species in each forest type can offer alternative remedies, which provides plant conservation, security and the possibility of reorganisation of their traditional medicinal knowledge. This case study showed the importance of considering folk systems and the role that this knowledge has played in plant resource management and forest protection. Different forests are used and valued differentially, not only with regard to usefulness but also in symbolic-religious terms, and together they fulfil a cushioning function, protecting holistically traditional botanical knowledge, people's health and forests. It is of great importance, therefore, that conservation policies favouring environmental heterogeneity are implemented, and that local inhabitants participate in the development of management plans.

Keywords Ethnobotany · Ethno-classification · Medicinal uses · Resilience

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Introduction

It has been clearly shown that the perceptions, values and attitudes of a culture regarding their natural environment influence their collective and interpersonal behaviour in the appropriation, use and conservation of resources (Davidson-Hunt and Berkes 2003; Nates et al. 2010). A classical approach to the study of environmental perception is the analysis of local ethno-taxonomy (Berlin 1992). This is based on the universal tendency of human beings to organise, classify and name the world around them, biotic and abiotic, according to their worldview (Berlin 1992; Cotton 1996).

Diverse studies have shown that the biophysical and sensorial characteristics of the world around us are interpreted and classified according to cultural parameters of special meaning to each society (Shepard 2004; Molares and Ladio 2009a), such as those which have emotional connotation (Nolan and Robbins 2001), those symbolic or taboo (Jain 2000; Khumbongmayum et al. 2005) and those that have importance as natural resources allowing self-sufficiency (Prescott-Allen and Prescott-Allen 1990; Lawrence et al. 2005; Ladio 2011).

For instance, many authors have taken a higher relative use value of species in an ecosystem as an indicator of higher cultural importance, and this has therefore been linked with competent environmental perception among dwellers (Berkes et al. 2000; Davidson-Hunt and Berkes 2003; Tengö and Belfrage 2004). But, this approach alone does not consider other culturally conditioned attitudes that play a significant role in the organisation of the landscape by people. Perception forms part of an intricate system in which culture receives permanent feedback from direct individual and collective experience with the environment, both practical and emotional, so its nature is flexible and holistic (Ingold 1996; Nolan and Robbins 2001; Berkes and Turner 2006).

The use of different ecological environments, their cultural perception and the traditional botanical knowledge generated in a society have been studied extensively (e.g. Benz et al. 1994; Ladio et al. 2007; Thomas et al. 2008). Nevertheless, little has been included of the idea that the use of diverse environments could act as a buffer system, a safeguard providing the body of plant knowledge of a population with a higher capacity of resilience. This concept, defined as the ability of socio-ecological systems to overcome changes and uncertainty (Berkes and Folke 2002; Tengö and Belfrage 2004; Eyssartier et al. 2011), may be intimately linked to perception of the diversity of ecological environments used by societies (Davidson-Hunt and Berkes 2003). Thus, a community could perceive and make use of different wooded environments as simply alternatives with differential uses, or these may act as sites with a redundancy of species and application options, and this would allow the culture to respond better to the dynamics of socio-cultural and environmental change (Tiwari et al. 2010).

The Mapuche have lived in the Andean Patagonian forests since prehispanic times and so these woodlands constitute their cultural landscape. In these environments they carried out small-scale agriculture, hunting and gathering, as well as spiritual and religious activities (Mösbach 1992). They have been considered great explorers and their spatial and temporal perception has enabled them to understand the dynamics of the forest and its components (Villagrán 1998; Ladio and Lozada 2003; Estomba et al. 2006). Their plant resources have served as medicines, food, dyes, tools, construction materials, etc., and so formed the base of their material culture (e.g. Martínez Crovetto 1980; Mösbach 1992; Citarella 1995; Ladio and Lozada 2001). In addition, the forests played a significant role within their cosmology, providing sacred sites inhabited by supernatural beings from whom this people originated, and also a burial place for the dead and family spirits

(Citarella 1995; Ladio and Lozada 2004). Many of the traditional ways the people had of relating to the forests changed, however, with European colonisation and the introduction of stockbreeding (Torrejón and Cisternas 2002). This activity led to the dividing up of land into sectors, partly for the placing of dwellings and the practice of horticulture, and partly for gathering activities and extensive stockbreeding (Bengoa 1991; Bandieri 2005).

In particular, *Nothofagus* forests are part of the cultural landscape of this people. Since ancient times, the health of Mapuche communities has been linked to the forest through the use of various species and their bio-compounds (Mösbach 1992; Houghton and Manby 1985; Ladio and Lozada 2008). Mapuche medicinal flora can be described as a body of knowledge which has been collectively established by consensus (Molares and Ladio 2009b), and whose composition depends mainly on the biological diversity of the environmental context (Ladio and Lozada 2008; Molares and Ladio 2009b).

This work is a case study of a Mapuche population which has access to three kinds of *Nothofagus* forest within its territory. Differing in their ecological–environmental characteristics little is known about the cultural and symbolical interpretations given to these forests, or to what extent they offer different biophysical and spiritual healing options. Taking Davidson-Hunt and Berkes (2003) into consideration, we hypothesise that for our study population, these forests will sustain a network of people, places and plants which will allow adaptive learning, creativity and resilience in the face of the different contexts of illness suffered by the inhabitants. As a result, dwellers see *Nothofagus* forest in a holistic and interconnected way and their medicinal plant knowledge is continually under construction at a local scale.

Thus, our objectives were: (1) To describe how the three types of *Nothofagus* forests are perceived, classified in local terminology and used in a rural community of Mapuche descent. (2) To analyse whether inhabitants consider that the three types of forest are similar in terms of species and/or redundant in functions, or whether each one has specific uses. (3) To compare cultural importance between forests and its relationship with the diversity of medicinal uses they offer. (4) To analyse whether cultural concepts relating to the use of the land and the different uses of the ecological environments have an influence on the resilience of the local medicinal flora.

Our main hypotheses were: (1) Forests of *Nothofagus* spp. are classified and named according to different symbolic and utilitarian criteria. (2) Each type of forest offers a particular range of species, used for specific ailments. (3) The cultural importance of the forests is not homogenous, and depends on the symbolic value of the medicinal plants found there. (4) The inhabitants' direct experience of the different forests and the community's worldview facilitate the resilient maintenance of the local medicinal flora.

Methods

Nothofagus spp. forests and the study site

The genus *Nothofagus* (Fagaceae) forms extensive woodlands in the lowlands and mountains of Chile and Argentina, New Zealand, the south of Australia, Tasmania, New Caledonia and New Guinea (Donoso et al. 2004).

In Argentina this genus occupies a narrow belt in the extreme west of Patagonia, extending from 33°S to 55°S, and in the east bordering with the Patagonian steppe (Correa 1998). It is represented by six species (*N. betuloides, N. pumilio, N. dombeyi, N. obliqua,*

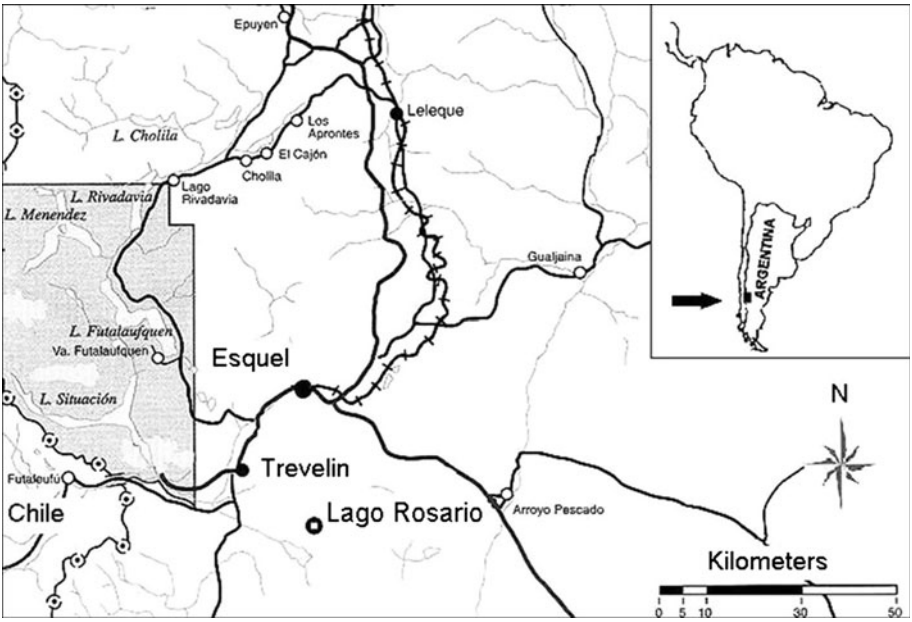

Fig. 1 Map showing the location of Lago Rosario community, Chubut Province, Argentina

N. nervosa and *N. antarctica*), which together make up practically 90% of Andean–Patagonian forests (Dimitri and Orfila 1985).

The present study was carried out in the community of Lago Rosario, situated in the northwest of Chubut province, Patagonia, Argentina (43°15′S, 71°21′W) (Fig. 1). This community is located in a valley in the Andean foothills, in a transition zone between southern deciduous forest and the western Patagonian steppe (Correa 1998). The climate is characterised by strong winds and frosts all year round, snow in winter, and a dry season in summer, with annual precipitations averaging 700 mm (Davel et al. 2002).

The population consists of 456 inhabitants, belonging to 127 households (INDEC 2001), and is made up principally of Mapuches and to a lesser extent, Creoles (descendants of European colonists and Mapuches). The dwellings are spread out around an area of 3,060 ha (Dirección General de Catastro e Información Territorial 2009).

The most important, accessible population centres are Esquel (50 km) and Trevelin (28 km) (Fig. 1), where the main shops, health, communication and education centres are found. The native language is Mapuzungun (“language of the land”), of the Nahuelpan linguistic tribe, but at present only 3% of the population actively speak it, and they are generally older, bilingual inhabitants (Díaz Fernández 2004).

The principal economic activity is livestock, with sheep breeding for the production of wool and meat. The local economy is complemented with temporary jobs taken on by the men in the shearing season, on ranches in other Patagonian provinces, between October and December each year. In addition, the state provides financial aid plans for women with children, on the condition that they complete the primary school programme, or carry out work, which is mainly the cleaning of community areas. Even so, between a third and a half of the rural adult population has not completed basic studies and lives in a situation where basic needs are not covered (INDEC 2001).

More information on the characteristics of the traditional medical system can be found in Ladio (2006) and Molares and Ladio (2009a).

Data collection

First of all, each person was asked for their informed consent before collaborating on this project, and was notified as to the characteristics and scope of the information to be requested, as well as the possible forms of communication of this information (Zent 2003). The information on the knowledge and therapeutic use of medicinal species, and also the ethno-classification and use, values and attitudes about forests was obtained by means of free listing and semi-structured and in-depth interviews (Alexiades 1996; Alburquerque et al. 2010) between December 2005 and February 2008. To this end, 30 informants over the age of 18 (average age $= 58 \pm 17$ years old) were selected at random from community residents.

The forest types were characterised and classified qualitatively by the residents themselves including the best characteristics that people use to distinguish each type. In addition, the main quantitative variables investigated were: the richness of medicinal plants, known and used per person, their vernacular names, uses and forests of origin.

The information obtained from the interviews was complemented with a survey of the plant species in the region, consisting of an inventory of the main species in each type of forest (Matteucci and Colma 1982; Ladio and Lozada 2000). Walks were taken with and without informants (Alburquerque et al. 2010), during which reference material was collected which was later placed in the herbarium of Comahue National University (BCRU).

The nomenclature and biogeographical origin (native or exotic to Patagonia) of these species was checked by consulting to Zuloaga et al. (2008). The Mapuzungun nomenclature was studied with the Augusta (1991) dictionary, and the aid of linguist Dr. Díaz Fernández.

Data analysis

The total richness of medicinal species and the richness of botanical families found in the forests were calculated using the total number of plants and families cited (Ladio and Lozada 2008). For the comparative analysis of medicinal plant species richness between forests, citations were classified according to their forest of origin (forests of *N. pumilio, N. antarctica* and mixed forest with *N. dombeyi*), as indicated by informants and our own observations. The total number of citations between forests was compared with the Chi-squared test ($p < 0.05$). The level of similarity between forests in terms of medicinal plant species richness was analysed with the Jaccard index (JI) $= c/(a + b + c) \times 100$, where c is the number of species in common, a is the number of species exclusive to forest A and b is the number of species exclusive to forest B (Höft et al. 1999). Therapeutic uses were divided into ten categories, which were established considering informants' indications and our own observations, and these were: gastro-intestinal and hepatic (GI), genito-urinal (GU), analgesic–anti-inflammatory (AD), dermatological–cosmetic (DE), febrifuge (F), gynaecological–obstetric (GO), circulatory system (SC), respiratory system (RE), cultural syndromes (SCU), and other uses: treatment of tumours, cholesterol, diabetes, cataracts, internal infections, earache, weakness, etc. (O).

Following Benz et al. (1994), estimations were made of the observed frequency of medicinal species (number of citations of medicinal species), the expected frequency (the number of citations expected if use category and forest type are independent), the residual

value (the difference between observed and expected frequencies) and the adjusted residual (the relation between residual value and estimated standard error) for each use category within each forest type. With these values, using the X^2 test ($p < 0.05$), the independence of medicinal use categories and forest types was tested.

In order to compare the cultural importance of the different forests, the following indices were calculated: (1) The consensus of each species per forest, with the formula: no. of informants who cite the species *i* for the forest considered/total no. of informants × 100. These values were later compared between forests using the Kruskal–Wallis test ($p < 0.05$). (2) The relative importance (RI) of each species (Bennett and Prance 2000) per forest, with the formula: RI = NBS + NP, where NBS is the number of body systems treated by a certain species (NBSS) divided by the number of body systems dealt with by the most versatile species (NBSVS); and NP is the relationship between the number of medicinal properties attributed to a given species (NPS) divided by the total number of properties attributed to the most versatile species (NPVS). Following this, in order to give weighting to the frequencies, the values of RI were multiplied by the consensus of each species per forest. The maximum value possible for this index is 200. The values obtained in this way were compared between forests with the Kruskal–Wallis test (modified by Albuquerque et al. 2008).

Results and discussion

Appropriation and use of forestlands

The lands that make up the Lago Rosario community are the common property of the inhabitants, and include pasturelands, domestic and public areas and forests. In practice, however, each family has charge of a part of the woodland, controlling in particular the resources growing there which can be used to feed livestock. Family subsistence depends on this regulation and so therefore does the principle source of income of each family, as has been registered in other studies (Arrue and Kalinsky 1991; Ladio and Lozada 2004). Similarly, Dillehay and Navarro (2003) found that in Chilean Mapuche populations on the Pacific coast, gathering rights in a particular area are controlled by a local chief ("lonko"), family or family line. These people regulate access to certain zones and the exploitation of particular resources according to land productivity, inherited rights, rules and beliefs.

A different situation is generated, however, with the areas where medicinal plants grow. Although these may be included within the dominion of a particular family, they are accessible to all community members, reflecting, in a way, the traditional community spirit of the Mapuche worldview, with generous bonds of reciprocity and solidarity (Arrue and Kalinsky 1991).

According to Galafassi (1994), this method of appropriation of resources expresses the existence of domestic control of assets related to the practice of livestock breeding, and social control of resources related to gathering. From the data mentioned above, it can be inferred that the perception of woodlands on the part of Lago Rosario community members is that of a collective territory, but of varying significance. Medicinal plant gathering is very probably one of the principal practices maintaining this cohesion in terms of the idea of shared land, belonging to everyone, reflecting a spatial pattern of their cultural landscape. In addition, the regular practice of searching for medicinal plants in this community demonstrates that it is considered generous land, rich in therapeutic resources, an idea of

abundance that is characteristic of their worldview, where everything is useful and exists on the "mapu" (earth) for a reason (Citarella 1995).

In addition, the community use of the land for medicinal plant gathering maintains a network of knowledge, people and practices that favours greater social and ecological resilience. Community control is more sustainable than individual, since it allows the community to respond to environmental signs in an adaptive way, adjusting practices, for example, according to the seasonal availability of plants within the territory, sharing knowledge and favouring exchange of the least available ones. This balance sustains greater knowledge of the environment. To the contrary, it has been shown that the rupture of this kind of community regulation and guidelines could result in competition and unequal appropriation of natural resources, generating territorial conflicts between neighbours (Aldunate et al. 1983), thus diminishing their capacity to deal with scarcity and change.

In this study, spatial perception for locals about where it is better to gather medicinal plant indicated that forest landscapes have a significant role. The body of knowledge of medicinal plants in this community includes 142 medicinal species (Molares and Ladio 2008), of which 55% (78 spp., representing 40 botanical families) are totally gathered in *Nothofagus* environments, which form part of the communal land (Table 1 in Supplementary material). Places and trails in these forests provide the reference points that orient the people to find specific medicinal resources but this knowledge is progressively updated to dwellers through their own experience on the land. The remaining species (64 spp.) are gathered in other environments, from the steppe or Patagonian Monte, are traded with inhabitants of other Mapuche communities, or are bought in general stores or herb shops in nearby cities.

Ethnoclassification of *Nothofagus* spp. forests used by Lago Rosario inhabitants

In accordance with our first hypothesis, the three forest types are named differently ("Ñirantal", "Lenganto" and "Koywal") and present particular characteristics in terms of richness of medicinal species and their uses. They are visited extensively, demonstrated by the numerous paths and trails leading to particular spots for the gathering of medicinal plants and other resources or activities. The informants described these in detail (100% of interviewees), indicating that they constitute a landscape that varies in significance, but that in their entirety the forests represent an integrative solution to their health problems. These are:

"Ñirantal": forest dominated by N. antarctica ("ñire")

Nothofagus antarctica is the dominant species, although other arboreal species are present, principally *Austrocedrus chilensis*, and to a lesser extent, *Lomatia hirsuta*, *Maytenus boaria*, *Schinus patagonicus* and *Discaria* spp. This environment has been profoundly altered, mainly because of cutting for firewood and overgrazing. The undergrowth is composed of a shrub layer of *Ribes* spp., *Berberis buxifolia*, *Fabiana imbricata*, *Senecio* spp. and *Baccharis obovata,* amongst other species. The herbaceous layer, on the other hand, is less developed due to overgrazing and trampling by sheep, and is composed of *Mutisia* spp., *Poa* spp., *Bromus* spp., *Solidago chilensis*, *Potentilla chiloensis*, among the most representative species. In the parts most affected by change, the absence of young stands is notable, as is the presence of elements typical of the steppe, like *Mulinum spinosum*, *Adesmia campestris*, *Acaena* spp., and a notable proliferation of exotic plants

and sub-shrubs, such as *Rosa rubiginosa*, *Artemisia absinthium*, *Taraxacum officinale*, *Erodium cicutarium* and *Plantago lanceolada*.

Tucked away in this forest is "the town", where most of the dwellings, the school, churches of different denominations (Catholic, Methodist, etc.), first aid centre, community centre, artisan workshop, police station and some grocery stores can be found. Spread out within the forest there are small groups of dwellings, generally grouped according to direct family relationships, who tend to share greenhouses, vegetable gardens, pasture land, corrals, henhouses, etc.

In this environment, livestock graze during most of the year, particularly in the colder season, approximately between April and November, known locally as the "invernada" (winter pasture), since at this height, at the bottom of the valley, less snow accumulates. From this forest type the firewood for domestic use and drinking and irrigation water are collected, and the most popular social activities are carried out, like competitions in riding skills, breaking-in of horses, religious festivals, etc.

From this forest, 57 medicinal species were registered. The most frequently cited species were the native *Fabiana imbricata* ("palo piche", 8.3% of all citations), used mainly as a diuretic, to cleanse the blood, for liver complaints and for washing the hair; *Baccharis obovata* ("wawtru", 4.7%), used for alopecia, for various forms of dermatitis and respiratory complaints; and *Equisetum bogotense* ("limpia plata", 4.7%), for digestive and kidney disorders. The exotic species were: *Artemisia absinthium* ("ajenco", 7.6%), used for digestive and liver complaints, as an antiparasitic, purgative and for the treatment of "empacho" (an acute liver and intestinal complaint); *Erodium cicutarium* ("alfilerillo", 6.5%), as a cicatrizant, for liver and digestive complaints and to purify the blood; and *Mentha pulegium* ("poleo", 4%), for digestive complaints and for "empacho" (Table 1 in Supplementary material).

Gathering is carried out mainly around dwellings, corrals and paths and on the pastureland, and to a lesser extent, on the riverside, "mallines" (wetlands of glacial origin), and in the "monte", which includes areas with bushy vegetation, often tangled. For our informants, access is easier and it is more practical to gather in the area around their houses, since in the "monte" walking is more difficult. At the same time, this differential use of the *N. antarctica* forest would seem to correspond to the mid-Andean concept that associates distant, unspoiled environments with the strange or hostile, and nearby ones with the familiar and safe (Crivos and Martinez 1997; Scarpa and Arenas 2004).

"Lenganto": forest dominated by N. pumilio ("lenga")

This forest develops at the highest altitudes in the area, until about 1,870 masl. The shrub layer is made up predominantly of *Berberis serrato-dentata*, *Gaultheria mucronata* and *Chiliotrichum rosmarinifolium*; and the herbaceous one of *Alstroemeria aurea*, *Geranium berteroanum*, *Calceolaria biflora*, and the fern *Polystichum plicatum*. At the highest point of its distribution, *N. pumilio* develops in a stunted form, and found here are species from the high Andean region, such as *Armeria maritima*, *Valeriana carnosa*, *Oxalis adenophylla*, *Berberis empetrifolia*, among others species. In patches, growth shows different levels of perturbation, due to fires, forestry exploitation and livestock.

In the open areas here which are less steep, the animals graze during "veranada" (summer pasturing), approximately between December and March, where there is better grazing than in the valley.

Wooden posts are taken from this environment for use in local construction of houses, sheds, etc. Edible mushrooms are also harvested for family consumption (e.g. *Cyttaria*

harioti, *Fistulina hepatica*), for ornamentation or the making of artefacts such as pin-cushions and handcrafts (*Phellinus* sp., *Postia* sp., etc.).

In addition, in this forest, normally with guns, the men hunt "puma" (*Puma concolor*), "red fox" (*Pseudalopex culpaeus*) and "condor" (*Vultur gryphus*), in order to obtain their skins, feathers or claws, which they sell to tourists or keep as trophies, or to prevent the attacks of these animals on the livestock.

In total 15 species were cited, all of native origin. The most frequently cited species were *Adesmia boronioides* ("paramela", 17%), used mainly for digestive complaints, colds, rheumatism and as a diaphoretic and antiemetic; *Valeriana carnosa* ("ñamkulawen", 17%), to "settle the blood" for ailments of the lungs, kidneys, heart, for knocks, for nicotine addiction, "for everything"; and *Baccharis sagittalis* ("carqueja", 12%), for liver complaints.

In general, the species from the "lenganto" are highly valued, preferred even when there are other species with similar properties close to the dwellings. Similarly, Albuquerque et al. (2005) found that inhabitants of a settlement in Brazil preferred to walk long distances to obtain certain medicinal species rather than use plants with the same properties growing in disturbed areas close to their settlement, showing that greater value is placed on native species used since ancestral times. In other words, as has been recorded for another community from the Andean Patagonian forest, the people will take great pains, in terms of distance and of time, to find species of high cultural value (e.g. Estomba et al. 2006).

Gathering is mainly carried out in the habitats situated at greater heights, called "pedreros" (stony areas) where the forest grows in stunted form and meets the High Andean flora. Nonetheless, it is worthy of mention that not all "pedreros" are preferred gathering sites, since some which are connected with caves or windows are considered "wild" sites on the mountain, and are perceived as dangerous because of evil spirits living there.

To a lesser extent, gathering also takes place in the understory destined for "veranada" and around the "posts" which are the shepherds' temporary settlements. As in the case of the "ñirantal", there is no gathering activity in the places where the vegetation is thicker or interwoven.

"Koywal at the head of the lake": Mixed forest with N. dombeyi ("koywe")

Nothofagus dombeyi is not dominant in the structure of the vegetation, although the name is derived from this species. This suggests that *N. dombeyi* must play an important symbolic role, as it is also scarce in other areas close to the communal lands.

In general, the livestock has little access to this forest, so it has maintained a good state of conservation, with young stands of the tree species present (*Maytenus boaria, Austrocedrus chilensis* and *N. dombeyi*), a well developed native herbaceous layer made up of the species *Geranium* spp., *Blechnum penna-marina*, *Mimulus luteus*, *Gunnera magellanica*, *Lathyrus magellanicus*, *Vicia nigricans*, *Equisetum bogotense* and a shrub layer of *Escallonia rubra*, *Aristotelia chilensis*, *Ribes magellanicum* and *Schinus patagonicus*, amongst others. In this environment neither stockbreeding nor agriculture is carried out, partly due to distance and difficult access to the houses.

In total 13 species were cited. The most cited native species were *Gunnera tinctorea* ("nalka", 21%), used mainly for the treatment of ailments of the lungs, kidneys, the treatment of "internal bruising", and as an analgesic for pain produced by severe knocks like falling off a horse, for example; *Baccharis sagittalis* ("carqueja", 15%), used for hepatic problems and *Equisetum bogotense* ("limpia plata", 15%), for hepatic and

digestive troubles and for "settling the blood". The most frequently cited exotic species was *Plantago major* ("llantén", 6%), used to calm the pain of knocks, and for hepatic, digestive and respiratory complaints.

Even though species richness is significantly lower than in other forests, it is worthy of note that for many informants this environment is a reservoir of plants which "cannot be found any longer in the town" such as *Aristotelia chilensis* ("make") and *Gunnera tinctorea* ("nalka"). Nonetheless, the difficult access to this region means that the species are not readily available for use, a frequent situation in rural Andean communities (Thomas et al. 2009).

Richness and similarity between *Nothofagus* spp. forests

In accordance with the second hypothesis, the *Nothofagus* spp. forests are taken advantage of in different ways. The highest richness for medicinal plant citations was recorded for the *N. antarctica* forest (64.5% of the total), followed by *N. pumilio* (26.2%) forest, and finally, the mixed forest with *N. dombeyi* (20.3%) ($X^2 = 133$, df = 2, $p < 0.01$).

The forests studied register low similarity values in terms of medicinal plant richness, varying between 1.4 and 9.7%. The mixed and *N. antarctica* forests are the most similar (9.7%), whereas the *N. pumilio* and *N. antarctica* forest are the least similar (1.4%). The mixed and *N. pumilio* forests register a similarity value of 3.6%. This low level of similarity indicates the importance of each forest with regard to their unique selection of medicinal species. The similarity between *N. antarctica* and the mixed forest may be on account of their greater similarity in terms of general floral composition.

Categories of medicinal uses and the relative importance of species in each gathering forest

Informants cited a total of 611 medicinal uses for the 78 species in the forests mentioned. These uses were divided into categories of therapeutic use and forest of origin (Table 2 in Supplementary material). In accordance with the second hypothesis, the statistical analysis revealed significant differences between forests with regard to cite frequencies for the different medical use categories ($X^2 = 60.4$; df = 18; $p < 0.001$).

In the *N. antarctica* forest, the species with the highest relative importance were *Fabiana imbricata* (RI = 1.8), *Equisetum bogotense* (RI = 1.5), *Erodium cicutarium* (RI = 1.4) and *Artemisia absinthium* (RI = 1.25). This forest provides a higher frequency of citations than expected for gastro-intestinal and hepatic uses, very likely due to the high frequency of *Artemisia absinthium*, *Equisetum bogotense*, *Mentha pulegium* and *Sisyrinchium patagonicum*; as well as for genitourinary uses, because of the high frequency of *Fabiana imbricata*, and for dermatological–cosmetic uses, mainly due to *Baccharis obovata*, *Erodium cicutarium* and *Fabiana imbricata* (Table 2 in Supplementary material).

The gastro-intestinal and hepatic category deserves special attention, since in general it is the most frequent for the Lago Rosario community (21% of cite total), in agreement with that observed in other Mapuche communities in Patagonia (e.g. Estomba et al. 2006; Ladio and Lozada 2008). Of the total number of species cited for this category, 68.5% are collected in this forest, which is possibly a reflection of its structure and composition, which includes an abundance of native and exotic weeds which have a recognised effect on gastro-intestinal and hepatic complaints (Molares and Ladio 2009a).

At the same time, the wide range of species used for this category in particular (33 species), suggests the existence of redundancy of use (Albuquerque and Oliveira 2007;

Júnior et al. 2011), a phenomenon which apparently relieves gathering pressure on few species, and therefore lessens the risk of over exploitation (Albuquerque and Oliveira 2007; Júnior et al. 2011). This phenomenon also reflects the high resilience or flexibility of local knowledge, which has incorporated new species of exotic origin into the traditional pharmacopoeia (Ladio and Lozada 2008).

As far as the *N. pumilio* forest is concerned, the species with the highest relative importance were *Valeriana carnosa* (RI = 2), *Adesmia boronioides* (RI = 1.8) and *Acaena splendens* (RI = 1.3). This forest provides a higher number of citations than expected for analgesic–anti-inflammatory uses, possibly due to the high cite frequency of *Adesmia boronioides* and *Valeriana carnosa*; febrifuge uses, due to *Oxalis adenophylla* and *Apium australe*, and the treatment of cultural syndromes, mainly because of *Chiliotrichum rosmarinifolium* and *Adesmia boronioides*. The link between the *N. pumilio* forest and the category of cultural syndromes in particular indicates that the community attaches special symbolic value to this forest, in accordance with our third hypothesis. Similarly, Aldunate et al. (1983) and Galafassi (1994) have drawn attention to the sacred character and the greater medicinal potential of higher altitude plants for other Argentinian indigenous societies. Crivos and Martinez (1997) have found that for certain Andean communities, natural phenomena "from above" are perceived as possessing greater power or strength compared with those "from below", which has an influence on aspects of everyday life, such as community health. According to Cotton (1996), symbols and ritual behaviour characterise the general collective feeling of societies, and in contrast to other behaviour patterns that may vary from person to person, these tend to be intra-culturally constant.

In the mixed forest, on the other hand, the species with the highest values for relative importance were *Equisetum bogotense* (RI = 1.5), *Gunnera tinctorea* (RI = 1.5) and *Plantago major* (RI = 1.1). This forest provides a higher number of citations than expected for respiratory uses, very probably due to the high cite frequency of *Gunnera tinctorea*, and febrifuge uses, because of *Oxalis adenophylla*.

The cultural importance of *Nothofagus* spp. forests

In accordance with our third hypothesis, the comparative analysis of values for cultural importance between forests indicates that they differ significantly ($p < 0.05$). The highest average consensus values and relative importance of species were obtained for the *N. pumilio* forest (average consensus = 26.4%, RI average = 30.5) and in second place was the *mixed forest* (average consensus = 22.3, RI average = 21.5), whereas the lowest values were found for the *N. antarctica* forest (average consensus = 16.4, RI average = 13.7). In contrast with that found by other authors (Villagrán et al. 2000; Martinez and Pochettino 2004), the highest regions did not contribute greater medicinal plant richness (Thomas et al. 2009). Instead, and in agreement with the aforementioned authors, the plants gathered from these heights had a greater use value than those collected lower down. This pattern suggests the central role of high regions in the magic and religious traditions of the Andes (Aldunate et al. 1983), and in particular, of the great therapeutic versatility of the *N. pumilio* forest, which would partly explain its higher cultural value.

Conclusions

This case study showed the importance of considering folk systems and the role that this knowledge has played in plant resource management and forest protection. This work not

only distinguishes classification patterns which reflect the differential use and value placed on different types of Andean Patagonian forests by a rural population of Mapuche descendants, but also shows that clear perception of the physical environment allows people to be more efficient and make use of a more diverse set of medical resources, with varying applications. Medicinal plant gathering practices in the forest both prevent illness and cure community members, and they also sustain connections between the landscape and the people, and with the history and their identity. This connection provide with a much greater capacity to self-mange thereby empowering them.

This study found that cultural perceptions of plant species are related to their geographical location, and together these convey information about their therapeutic properties. These findings contribute new evidence about the relationships between methods of use, ecological conditions and cultural precepts in Mapuche societies (Dillehay and Navarro 2003). A complex pattern of medical plant selection and use can thus be drawn up, which could also favour the resilience of the local medicinal flora, which has strong implications for bio-cultural conservation (Ladio and Lozada 2008). The species diversity and redundancy of uses offered by these three forest types together allow inhabitants to withstand changes in species abundances and continue to be self-sufficient in domestic medicine.

The environmental heterogeneity observed includes patches with a different level of conservation, which is probably a consequence of the particular way of life and beliefs of the population. On the one hand, the community exercises deforestation pressure on their surroundings due to the extraction of scarce subsistence resources such as firewood and pasture for their animals, a result of the reduction in lands allocated to them by the government (Armesto et al. 2001; Molares and Ladio 2009a, b). On the other hand, the diversity and functional redundancy of the species used is notable. The kind of social control of the territory for medicinal plant gathering, showing solidarity and reciprocity, indirectly implies behaviour resulting in careful use of the flora. As well as this, the population protects certain sacred sectors of the forest, favouring its conservation. Several authors (e.g. Byers et al. 2001; Colding and Folke 2001; Ormsby and Bhagwat 2010; Tiwari et al. 2010) have recorded that sacred forests are generally found to be in a better state of biological and cultural conservation than those not considered special in this way. In the case of the Mapuche, this is particularly prevalent, given that according to their cosmology, man and his environment represent one unit; therefore, respect for nature would be one of those aspects most highlighted amongst behaviour guidelines relating to health care (Citarella 1995).

It is important to point out, however, that these communities are currently undergoing many changes, mainly due to the loss of part of their traditional lands, and also due to the effects of a market society that demands natural resources from rural areas, exercising over-exploitation pressure. In the short term, these factors possibly modify the patterns observed in this study.

All this being considered, it is of paramount importance to implement conservation policies that preserve environmental heterogeneity and the social, economical and territorial equity of these communities. From this perspective, the link between human populations living in ecosystems at risk and the elaboration and implementation of environmental policies takes on great relevance (e.g. Albuquerque 1999; Ezebilo 2010).

In addition, it has been shown that when communities are excluded from the environment they always lived in, or their practices are forcibly modified, the traditional way of life changes drastically and the people gradually move away from their natural practices, even becoming aggressive towards the resources they had always protected (Albuquerque 1999).

For this reason, any bio-cultural conservation should take into account the importance of respecting traditional values and spiritual leaders (Byers et al. 2001), the stimulation of practices that favour connection with the environment (Tuan 1980), and the right to ownership of inhabited lands and the use of their natural resources (Ross and Pickering 2002).

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