

The lleuque forests of South Central Chile: a phytosociological study and syntaxonomical classification within South American temperate forests

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Abstract: Amigo, J., Rodríguez-Gutián, M.A. & Ramírez, C. *The lleuque forests of South Central Chile: a phytosociological study and syntaxonomical classification within South American temperate forests. Lazaroa 31: 85-98 (2010).*

This paper is a phytosociological study of a forest community dominated by the *lleuque* (the Araucanian name for the podocarpaceae *Prumnopitys andina*). This is a mixed forest community with gymnosperm and broad-leaved trees growing in a temperate sub-Mediterranean climate, with a somewhat continental character within the very oceanic territory of Chile. The paper describes the new *Nothofago obliquae-Prumnopitydetum andinae* association, mostly located between the Bío-Bío and La Araucanía regions (parallels 36° to 40° south). We deal with the bioclimatic characteristics of the community, its biogeographical restrictions and its continuing presence in special topographical sites. The paper not only analyzes the floristic composition of the community in order to ascribe it syntaxonomically to the *Wintero-Nothofagetea* class, but also considers a number of floristic arrangements which support a reinterpretation of some syntaxa which are phytosociologically ranked as orders or classes.

Key words: *Prumnopitys andina*, endangered flora, continental forests, temperate forests, *Wintero-Nothofagetea*, *Nothofagetea pumilionis-antarcticae*.

Resumen: Amigo, J., Rodríguez-Gutián, M.A. & Ramírez, C. *Los bosques de lleuque del Centro-Sur de Chile: estudio fitosociológico y posición sintaxonómica dentro de los bosques templados de Sudamérica. Lazaroa 31: 85-98 (2010).*

Se presenta el estudio fitosociológico de una comunidad de bosque presidida por el lleuque (nombre de origen araucano de la podocarpácea *Prumnopitys andina*). Se define como un bosque mixto con mezcla de gimnospermas y planifolios, de tipo templado sub-Mediterráneo y con cierto matiz de continentalidad dentro de un territorio tan oceánico como Chile. Se describe una nueva asociación denominada *Nothofago obliquae-Prumnopitydetum andinae* con una distribución principal entre las regiones del Bío-Bío y la Araucanía (paralelos 36° a 40° Sur); se comentan las características bioclimáticas, sus limitaciones biogeográficas y su persistencia en posiciones topográficas peculiares. Además de analizar su composición florística para su encuadre sintaxonómico dentro de la clase *Wintero-Nothofagetea* se realizan consideraciones sobre algunos colectivos florísticos que apoyan reinterpretaciones de algunos sintaxones del rango de orden o de clase fitosociológica.

Palabras clave: *Prumnopitys andina*, flora amenazada, bosques continentales, bosques templados, *Wintero-Nothofagetea*, *Nothofagetea pumilionis-antarcticae*.

INTRODUCTION

The lleuque [*Prumnopitys andina* (Poepp. ex Endl.) de Laub] is a gymnosperm, a practically en-

demic plant of Chile, which occurs in some temperate forests located on a strip of land extending approximately from parallel 35° 50' to 40° 30' south (CONAF 1998). It grows mostly in the lower va-

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lleys of the Andean Cordillera and, to a much lesser extent, in rain shadow sites of some areas of the Cordillera de la Costa (Nahuel Buta and Cordillera Pelada), under extremely difficult conditions for its

survival (Figure 1). In a comprehensive assessment following UICN criteria (HECHENLEITNER & al., 2005), the lleuque populations have recently been ranked as vulnerable, VU (B2ab).

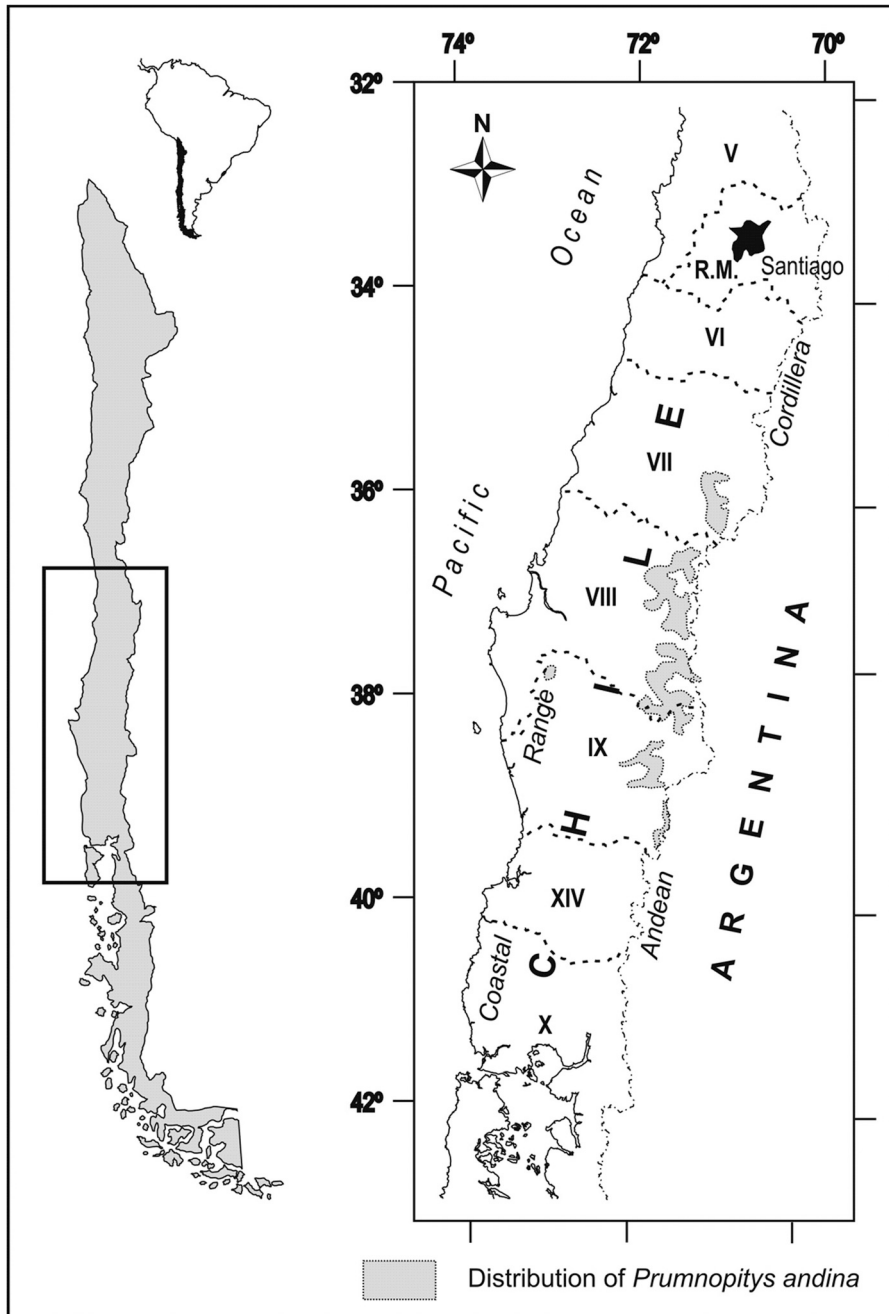


Figure 1.– Location of natural populations of *Prumnopitys andina* in Chilean territory. Based on CONAF (1998), HECHENLEITNER & al. (2005) and on our own data.

Prumnopitys andina, the most suitable name for this plant species belonging to the Podocarpaceae family, should prevail over *Podocarpus andina* or *Prumnopitys spicata* (see MILL & QUINN 2001). General works, such as those by DONOSO (1983), RODRÍGUEZ & al. (1983), RODRÍGUEZ (1988) or RODRÍGUEZ & QUEZADA (1995), have already sufficiently described this Chilean (and only in very specific places) Argentinian tree (ZULOAGA & MORRONE 1996) with regards its botanical and morphological characteristics (leaves, flowers, etc.). However, these descriptive approaches deal very little with the tree's sociological behaviour or companion species (apart from some brief comments on its ecological requirements). As a result of the ecological preferences of the tree, it seldom gives rise to extensive formations, a fact which has made the tree appear to be of minor importance not only for descriptive works dealing with Chilean vegetation (GAJARDO, 1994), but also for works to classify it for forestry purposes (DONOSO, 1981).

Recent studies confirmed by experts such as HECHENLEITNER & al., (2005) suggest that the lleuque is geographically an extremely restricted coniferous tree, after only the pehuén (*Araucaria araucana*) and the alerce (*Fitzroya cupressoides*), the most restricted of all. Consequently, we must dismiss prior interpretations which allegedly recorded its occurrence as far as parallel 45° south (WOLTZ, 1985) as incorrect and obviously based on confusion with another species endemic to Chile: *Podocarpus nubigena*. Whereas alerce and pehuén are large-sized, coniferous tree species (adult individuals can grow up to 30 metres or more) capable of dominating forest masses over their angiosperm companions, the lleuque barely reaches 20 m at the most, and usually only reaches 12-16 m in height. The lleuque is therefore forced to co-exist in its distribution area with other potentially taller tree species such as the roble (*Nothofagus obliqua*), the coihue (*Nothofagus dombeyi*) and even the ciprés de la cordillera (*Austrocedrus chilensis*).

More than two decades ago, one of the authors proposed an association characterized by the lleuque. In a phytosociological synthesis, RAMÍREZ & FIGUEROA (1985) suggested the association named

Prumnopito-Nothofagetum obliquae nomen nudum, which was basically characterized by the occurrence of Chilean oaks associated with these coniferous trees. Since there were no supportive relevés at the time, the proposed association was invalid according to the requirements of the Code of Phytosociological Nomenclature (WEBER & al., 2000) and remained as a *nomen nudum*. The name was hardly ever used again in any descriptive botanical work. The only exception was a compilation by LUEBERT & PLISCOFF (2006), who mentioned it as one of the zonal communities which could be found in the territorial area of their unit 54: "Temperate, caducifolious *Nothofagus obliqua* and *Laurelia sempervirens* forest".

Aware of the content vacuum around the *nomen nudum* status, we took up the topic again and carried out a number of relevés in order to properly define the floristic composition, map the chorological distribution and determine the bioclimatic preferences, dynamic aspects and possible exploitation of these wood formations where lleuque occurs. Our records suggest that all these characteristics indicate a genuine phytosociological association.

METHODOLOGY

We explored the areas of Chile where the occurrence of lleuque had been massively recorded. For this purpose we visited different areas of the valleys at the foot of the Andean Cordillera throughout the regions of Bío-Bío and La Araucanía (VIIIth and IXth regions, respectively, in the Chilean administrative arrangement; see Figure 1). Our aim was to sample plant formations with a considerable presence of lleuque trees, with a more or less natural appearance and a homogeneous wood mass, dismissing any man-induced discontinuities. In these sites we made relevés using the phytosociological method of BRAUN-BLANQUET (1979), later updated by GÉHU & RIVAS-MARTÍNEZ (1981).

To determine the species growing in each sampling area we followed the nomenclature suggested by MARTICORENA & QUEZADA (1985) and MARTICORENA & RODRÍGUEZ (1995, 2001, 2003

and 2005). For syntaxonomical purposes, we complied with the directives of the 3rd edition of the Code of Phytosociological Nomenclature (WEBER & al., 2000).

RESULTS

The *lleuque* populations in the Cordillera de la Costa are so small and their natural environment has been so dramatically altered by *Pinus* reforestation that we will omit the forest relevés including this species in this area of Chile. In the distribution area, in the foothills of the Andean Cordillera, there are occasional forest patches dominated by *lleuque* trees (and variably shared with broad-leaved species, mostly belonging to the *Nothofagus* genus). As we will discuss later, *Prumnopitys andina* tends to grow on the lower levels of the mountain slopes, that is, where it can most easily form extensive populations on considerably large sites. However, in the pre-Cordilleran valleys where the community has its optimum, natural environments have also been dramatically altered by the native *mapuche* population. For this reason, although scattered mature trees and sometimes even tree copses are frequently found, the understorey has often been reduced to a minimal expression by cattle-farming (goats, cows and horses) activities. Examples are abundant in all the river valleys with headwaters in the Andean pre-Cordillera. We have found *lleuque* copses, for instance, in the valleys of the rivers Ñuble, Queuco, Bío-Bío and Toltén.

In spite of all this, we were also able to sample some sufficiently natural formations in which, as they were in topographical locations which were fairly inaccessible to cattle, human action seems to have had little or no impact on the configuration of the forest. Table 1, with a total of 14 relevés, comprises all these samples supporting our proposal for the new association *Nothofago obliquae-Prumnopitydetum andinae* Amigo, Rodríguez-Gutián & Ramírez ass. *nova hoc loco* (*holotypus* rel. 7, Table 1).

The new community shows not only the constant affinity of *lleuque* for *roble* (*Nothofagus*

obliqua) but also the ability of *lleuque* to join up with other trees having rather opposite ecological preferences. An example is *coihue* (*Nothofagus dombeyi*), with which it forms more shady arrangements as a result of their shared evergreen character. It also joins up with the *ciprés de la cordillera* (*Austrocedrus chilensis*), a more heliophilous and to a certain extent xerophilous species. This last matching reveals a somewhat sub-Mediterranean influence in the formations shared by these coniferous trees.

DISCUSSION

ABOUT THE HABITAT

We think that it is correct to say that *Prumnopitys andina* grows "mostly at the bottom of valleys near large rivers" (HECHENLEITNER & al., 2005). However, the forest patches in which this coniferous tree may become dominant show an edaphotopographical peculiarity: they tend to be located on colluvial deposits of large rocky blocks, often at the foot of cliffs or steep slopes (Figure 2), in an ecological environment which resembles the European forests belonging to the *Tilio-Acerion* Klika 1955 (ELLENBERG, 1988) alliance. The *lleuque's* ability to germinate and develop on deep, very stony soils has probably provided it with efficient survival options to defend itself against the human colonization of the valley floors and the usual activities that ensue: land deforestation, farming and cattle-raising and human settlement. It is well known that in sites which have been partly deforested for cattle-farming activities but where adult *lleuque* trees have been maintained, these trees no longer regenerate because pigs and goats eat their fleshy seeds (HECHENLEITNER & al., op. cit., Figure 3).

ABOUT THE CHOROLOGICAL AND BIOCLIMATIC DIAGNOSIS

The new association suggested is endemic to the temperate territory, which is more or less coincidental with the Subantarctic Province in the biogeographical arrangement by CABRERA &



Figure 2.— Preferential topographical locations of the *Nothofago obliquae-Prumnopitydetum andinae* forests under study.

WILLINK (1973), or the Valdivian-Magallanic Region, according to the chorological scheme suggested by Rivas-Martínez (see in COSTA, 2004). In default of other more detailed biogeographical sectorization models, in the mapping suggested by LUEBERT & PLISCOFF (2006) this association would be part of the "Caducifolious forest" plant formation and of the vegetation belt called "Caducifolious temperate *Nothofagus obliqua* and *Laurelia sempervirens* forest" (hereafter "forest no. 54 roble-laurel").

The bioclimatic indexes of sites not only on the mountain peaks but also on the foothills of the Cordillera cannot be accurately calculated as there are no suitable weather stations in the Andean areas of Chile. Nevertheless, the records measured at the nearby Lonquimay weather station (AMIGO & al., 2007a), at an altitude of 900 m, 38° 26' south and 71° 15' west, can be taken as approximate values. According to the scheme suggested by RIVAS-MARTÍNEZ (1993, 2007, On-

Line), these bioclimatic records clearly belong to the upper supratermperate ($T_p = 1005$) and upper hyperhumid ($I_o = 19.1$) ranges. Taking into account these records and the sampled altitudinal range (630-925 m), the geographical areas colonized by the *Nothofago obliquae-Prumnopitydetum andinae* association show a bioclimatic profile which corresponds to a supratermperate thermotype. Consequently, we categorically reject the subordination of the name "*Prumnopyto-Nothofagetum obliquae*" with its vegetation belt "forest no. 54 roble-laurel" suggested by LUEBERT & PLISCOFF (op.cit.), since these authors ascribe fluctuation ranges of $I_{tc} = 223-273$ and $T_p = 1238-1440$ to that belt. These values clearly correspond to a bioclimatically mesotemperate belt.

The clearest bioclimatic peculiarity associated with the distribution of *lleuque* forests is a certain degree of continentality. Most of the territories where they occur (we exclude here the vestigial sites of the Cordillera de la Costa) are clearly se-

Table 1
Nothofago obliquae-Prumnopitydetum andinae ass. nova
 (Austrocedro-Nothofagion dombeyi, Berberido trigonae-Nothofagetalia dombeyi, Wintero-Nothofagetea)

	630	735	800	925	725	800	800	865	760	750	830	730	860	750	Frequency	
Altitude (m a.s.l.)	630	735	800	925	725	800	800	865	760	750	830	730	860	750		
Slope (°)	16	30	35	10	34	40	40	35	15	10	30	26	5	32		
Aspect	SE	NE	WSW	NNE	NE	NE	SSW	NNE	NE	SSE	W	NNW	SW	ESE		
Cover (%)	100	100	90	95	100	95	90	90	90	100	95	95	80	70		
Vegetation height (m)	18	12-14	12-22	20-28	16-18	15-26	15-20	15-17	12-15	12-14	14-20	15-20	10-18	8-13		
Plot area (m ²)	200	200	500	500	300	300	250	250	120	200	400	300	100	100		
N° of species	32	26	22	23	23	28	30	25	25	24	25	15	18	21		
N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
Dominant trees																
<i>Prumnopitys andina</i>	5	4	4	4	5	5	5	5	5	3	5	4	3	+		14
<i>Nothofagus obliqua</i>	2	2	2	1	2	1	3	1	+	4	3	4	1	2		14
<i>Austrocedrus chilensis</i>	.	.	.	+	.	+	+	+	.	1	2	.	2	4		8
<i>Nothofagus dombeyi</i>	2	2	3	3	+	2		6
Characteristics of association and upper units																
<i>Chusquea culeou</i>	1	1	3	2	1	1	+	3	1	.	2	1	.	.	11	
<i>Osmorhiza chilensis</i>	2	+	1	2	1	1	1	2	+	.	1	1	.	.	11	
<i>Blechnum hastatum</i>	1	2	1	1	2	1	.	.	2	1	.	2	.	+	10	
<i>Alstroemeria aurea</i>	+	r	+	+	+	+	+	.	+	r	.	.	.	.	9
<i>Lomatia hirsuta</i>	.	+	2	2	.	.	3	2	1	1	2	.	.	1	9	
<i>Myoschilos oblonga</i>	.	1	1	1	.	+	+	1	.	1	1	.	.	.	8	
<i>Maytenus chubutensis</i>	.	.	+	1	.	.	+	1	.	1	+	.	.	+	7	
<i>Polystichum plicatum</i>	.	+	1	1	+	.	1	.	+	.	+	.	.	.	7	
<i>Relchela panicoides</i>	.	.	1	+	.	+	+	1	.	.	1	.	.	.	6	
<i>Viola maculata</i>	.	1	r	+	.	.	+	+	.	.	+	.	.	.	6	
<i>Calceolaria filicaulis</i>	.	.	.	+	r	+	+	+	.	.	.	.	.	.	5
<i>Mutisia decurrens</i>	.	.	+	r	.	.	+	.	.	+	r	.	.	.	5	
<i>Schinus patagonicus</i>	.	.	.	+	r	.	.	r	.	+	r	.	.	.	5	
<i>Lomatia dentata</i>	r	.	.	.	.	.	.	.	.	.	.	+	3	1	4
<i>Vicia nigricans</i>	.	.	1	.	.	+	+	.	.	.	+	.	.	.	4	
<i>Lathyrus subandinus</i>	.	.	+	+	.	.	.	1	.	.	.	.	.	.	3
<i>Sanicula crassicaulis</i>	+	.	.	.	.	1	.	.	.	.	.	+	.	.	3
<i>Pseudopanax laetevirens</i>	r	.	.	.	+	.	.	.	.	.	.	.	.	.	2
<i>Adenocaulon chilense</i>	1	.	.	.	.	.	.	.	+	.	.	.	.	.	2
<i>Bowlesia tropaeolifolia</i>	.	.	.	.	.	+	1	.	.	.	.	.	.	.	2
<i>Cystopteris fragilis</i>	.	.	.	.	.	+	+	.	.	.	.	.	.	.	2
<i>Trisetum caudulatum</i>	.	.	.	.	.	.	1	.	.	.	1	.	.	.	2
<i>Carex patagonica</i>	.	.	.	.	.	.	.	1	.	.	r	.	.	.	2
Aristotelienea species																
<i>Relbunium hypocarpium</i>	+	.	+	+	r	1	1	+	+	+	1	r	.	.	11	
<i>Azara microphylla</i>	2	1	1	1	+	1	+	.	+	1	1	.	.	.	10	
<i>Aristotelia chilensis</i>	1	1	.	.	1	1	+	.	1	2	1	1	2	.	10	
<i>Ribes gr. valdivianum</i>	1	+	+	+	+	.	+	r	+	+	.	.	+	.	10	
<i>Berberis darwini</i>	+	+	1	.	.	.	+	.	1	+	+	.	.	.	7	
<i>Rosa rubiginosa</i>	+	.	.	.	.	+	r	+	.	+	+	+	.	.	7
<i>Berberis microphylla</i>	.	.	.	.	.	+	r	+	.	+	.	.	.	.	4
<i>Boquila trifoliolata</i>	1	r	.	.	1	.	.	.	1	.	.	.	.	.	4
<i>Myrceugenia nanophylla</i>	1	1	.	.	.	.	.	.	1	.	.	.	.	.	3
<i>Azara integrifolia</i>	.	.	.	.	.	.	.	.	.	+	.	1	.	1	3
<i>Fuchsia magellanica</i>	+	+	.	.	.	.	.	.	.	.	.	.	.	.	2
Companion species																

N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
<i>Adiantum chilense</i>	·	1	·	·	+	+	·	·	+	·	·	+	·	·	5
<i>Dactylis glomerata</i>	1	1	·	·	1	+	·	·	1	·	·	·	·	·	5
<i>Acaena ovalifolia</i>	+	1	·	·	·	·	·	·	+	·	r	·	·	·	4
<i>Prunella vulgaris</i>	+	+	·	·	+	+	·	·	·	·	·	·	·	·	4
<i>Solanum cyrtopodium</i>	+	+	·	·	·	+	·	·	·	·	·	·	·	·	3
<i>Carex aphylla</i>	·	·	·	+	·	·	·	·	·	·	·	+	·	1	3
<i>Leucheria caerulescens</i>	·	·	+	·	·	·	1	·	·	·	·	·	·	1	3
<i>Valeriana cf. valdiviana</i>	·	·	·	·	1	·	+	·	1	·	·	·	·	·	3
<i>Gaultheria phyllireifolia</i>	+	·	·	·	·	·	r	·	+	·	·	·	·	·	3
<i>Lapsana communis</i>	·	+	·	·	+	·	·	·	1	·	·	·	·	·	3
<i>Adiantum scabrum</i>	·	·	·	·	·	·	·	·	·	·	·	+	·	1	2
<i>Gavilea sp.</i>	·	·	·	·	·	+	·	·	·	1	·	·	·	·	2
<i>Dioscorea sp.</i>	1	r	·	·	·	·	·	·	·	·	·	·	·	·	2
<i>Asplenium dareoides</i>	+	·	·	·	+	·	·	·	·	·	·	·	·	·	2
<i>Agrostis leptotricha</i>	·	·	+	·	·	·	·	·	·	·	·	·	·	1	2
<i>Nasella chilensis</i>	·	·	·	·	·	·	·	·	·	·	·	1	+	·	2
<i>Acaena argentea</i>	·	·	·	·	·	+	·	·	·	·	·	·	+	·	2
<i>Cynanchum pachyphyllum</i>	·	·	·	·	·	·	·	·	+	1	·	·	·	·	2
<i>Equisetum bogotense</i>	·	1	·	·	·	·	·	+	·	·	·	·	·	·	2

Other species: Characteristics species *Azara lanceolata* r, *Blechnum mochaenum*, *Blechnum penna-marina* and *Rhapthamnus spinosus* +, *Luma apiculata* 1 in 1; *Elymus andinus* + in 4; *Anemone multifida* + in 8; *Embothrium coccineum* 1 in 9; *Berberis rotundifolia* r in 11; *Gevuina avellana* r, *Aextoxicon punctatum* +, *Drimys winteri* and *Muehlenbeckia hastulata* 1, *Laurelia sempervirens* and *Podocarpus saligna* 2, *Hydrangea serratifolia* 3 in 13; *Dios-tea juncea* + in 14. Companion species: *Polypodium feuillei* + in 5; *Loasa sp.* r, *Geranium robertianum* and *hem-cryptophyte* unknown + in 6; *Asteracea sp.* and *Stellaria sp.* + in 7; *Holcus lanatus* and *Hypericum perforatum* +, *Lactuca serriola* 1 in 8; *Festuca scabriuscula* +, *Lotus uliginosus* 1 in 9; *Pernettya myrtilloides* and *Poacea sp.* +, *Rumohra adiantiformis* 1 in 10; *Poa gr. trivialis* + in 11; *Cirsium arvense*, *Solanum gr. gayanum* and *Tristerix te-trandrus* + in 13; *Baccharis concava*, *Cheilanthes glauca*, *Chusquea cumingii*, *Oxalis araucana* and *Satureja gilliesi* +, *Sophora macrocarpa* 1, *Gochnatia foliolosa* and *Quillaja saponaria* 2 in 14.

Localities (author's code for relevés is included): 1, 2, 5, 9 and 10: La Araucanía, Cautín, from Cahuilefún towards Curarrehue, 39°15'-71°26' (070124/1); from Reigolil towards Curarrehue, 39°11'-71°27' (070123/4); 39°12'-71°27' (070123/5); from Reigolil towards Curarrehue, 39°11'-71°27' (090122/3); Conguillío National Park, Southwards exit to Melipeuco, 38°45'-71°37' (070119/2); 3, 4, 6-8 and 11: La Araucanía, Malleco, Bio-Bio river valley, Casas de Lolco, 38°08'-71°24' (090120/3); from Troyo Northwards, 38°10'-71°18' (090120/2); between Contraco and Lolco, 38°08'-71°20' (070118/5); Bio-Bio river valley, from Troyo Northwards, 38°11'-71°18' (070118/3), *holoty-pus ass.* Bio-Bio river valley, from Lonquimay towards Troyo, 38°19'-71°19' (090119/1); Nalcas National Reserve, from Casas de Lolco towards Lonquimay. 38°11'-71°26' (090120/4); 12: Bío-Bío, Bío-Bío: river Queuco valley upwards, close to Comuna Cauñico, 37°43'-71°23' (070117/1); 13 and 14: Bío-Bío, Ñuble: entrance to Ñuble National Reserve, 36°58'-71°30' (080119/1); Ñuble valley upwards, a little downwards from Los Sauces, 36°40'-71°16' (070115/2).

mihyperoceanic, sometimes even euoceanic. At the Lonquimay weather station, the Ic = 14.0, that is, the threshold value between semihyperoceanic and euoceanic conditions. All these temperate territories are also bioclimatically characterized by their sub-Mediterranean character, that is, they undergo a certain degree of water deficit in summer time. Although there are no accurate weather records available, the distribution of *Prumnopitys andina* tends clearly to coincide with the non-co-

astal area described by LUEBERT & PLISCOFF (*op.cit.*: 66, Figure 14) as having a temperate sub-Mediterranean bioclimate.

ABOUT THE FLORISTIC COMPOSITION

Although the analysis shown in Table 1 reveals some variability, the community as a whole presents a constant occurrence of nemoral species. In other words, the community is able to



Figure 3.— Detail of seminiferous branches of *Prumnopitys andina*.

maintain an acceptable forest structure which becomes less defined as the sub-Mediterranean conditions become more apparent, and the copse physiognomy changes due to the progressively dominant presence of *Austrocedrus chilensis*. The combination of a coniferous tree, with a higher cover rate, and a deciduous species, such as *Nothofagus obliqua*, gives rise to a myriad of understorey microhabitats with extraordinarily changing light conditions (Figure 4) and very different contributions of dead leaves. The phenomenon is particularly prominent because it also frequently takes place on very irregular microtopographical terrains with abundant large rocky outcrops. These microhabitats induce the occurrence of species belonging to the whole range of biotypes peculiar to a temperate forest. Included in this last group, the scrub species which present their optimum in the wood mantles of temperate forests *sensu lato* are the most noteworthy. Given their autoecological profile,

these species occur very frequently, albeit with a low cover ratio, in woodland understoreys such as those of *Nothofago-Prumnopitydetum*, where light availability varies considerably from one place to another. In Table 1 we have highlighted the occurrence of these nanophanerophytes by placing them apart as representatives of communities belonging to the *Aritotelienea chilensis* subclass. The association which is usually noteworthy as its mantle scrub is the *Azaro microphyllae-Aristoteliatum chilensis*, whose distribution in continental areas not subjected to extreme low temperatures had previously been related to the occurrence of *roble-lleuque* forests (AMIGO & al., 2007b).

There are also many examples of species which grow in the dense shade at the foot of the *lleuques* and therefore grow less vigorously or at a lower phenological rate, and do not develop all their flower or fruit organs. Consequently, they cannot be properly identified as distinct species.

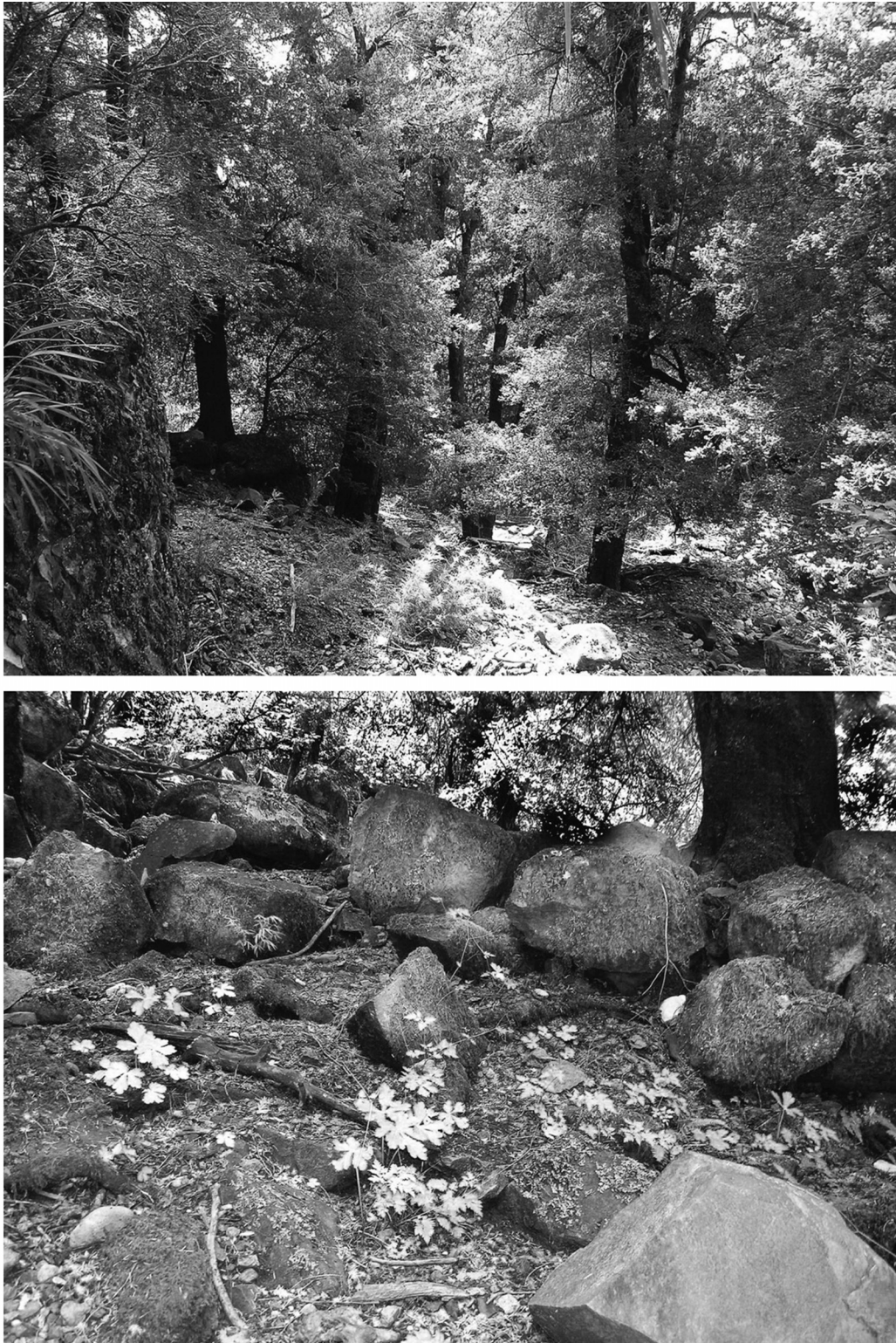


Figure 4.— Internal appearance (top) and detail of the understorey (below) of the *lleuque* forests under study.

Table 1 also reveals that the northernmost relevés show the smallest number of species. This is probably because not only is there a smaller surface suitable for making relevés in these sites but also because the coniferous trees "*Prumnopitys andina* and *Austrocedrus chilensis* form marginal forests at the dryness limit of the forest region north of 37,5° south" (HILDEBRAND-VOGEL, 2002: 119). Not surprisingly, in Table 1 relevés 13 and 14, taken on land plots of just 100 m² in sites north of parallel 37°, have not only the poorest flora of all but also, as a result of their extreme northern location, some of the more spurious species with respect to the usual profile of the association. Relevé no. 13 shows, for example, the occurrence of species such as *Aextoxicon punctatum*, *Laurelia sempervirens*, *Gevuina avellana* or *Podocarpus saligna*, all belonging to *Nothofago-Eucryphion cordifoliae*, the most clearly thermophilous flora arrangement within the *Wintero-Nothofagetea* class. In relevé no. 14 the influence of a markedly sub-Mediterranean temperate bioclimate is not only revealed by the dominance of the *ciprés de la cordillera* (*Austrocedrus chilensis*) but also by the presence of species peculiar to the sclerophyllous forests belonging to the *Lithraeo-Cryptocarpacea* class, such as *Quillaja saponaria*, *Sophora macrocarpa*, *Chusquea cumingii*, *Gochnatia foliolosa*, or its sucesional stages.

ABOUT THE SYNTAXONOMICAL CLASSIFICATION

With regard to the syntaxonomical classification, we think that the largest number of species relates the *Nothofago obliquae-Prumnopitydetum* to the *Wintero-Nothofagetea* class, although for a correct ascription to this class we accept the following assumptions:

- 1) The interpretation by POLLMANN (2001) is correct in extending the *Wintero-Nothofagetea* class in order to include a series of forests dominated by species which belong to the *Nothofagus* genus, and present a colder and more continental profile due to the fact that they grow in Argentinian territory. This author defined the *Berberido trigonae-No-*

thofagetalia dombeyi order to comprise several associations suggested by ESKUCHE (1968, 1973) as belonging to the *Nothofagetea pumilionis-antarcticae* class.

- 2) The supratemperate Argentinian forests dominated by different species belonging to the *Nothofagus* genus, and even by *Austrocedrus chilensis* in temperate territories, should be more closely related to their vicariant instances growing in Chile. This can easily be done by subordinating a series of species peculiar to the *Nothofagus* forests growing on the temperate strip of land in Argentinian territory to the *Wintero-Nothofagetea* class. However, in the past some researchers of that trans-Andean territory (ESKUCHE, 1968, 1973 and 1999; CONTICELLO & al., 1996) have opted to include these series in the *Nothofagetea pumilionis-antarcticae* class.
- 3) *Nothofago obliquae-Prumnopitydetum* should therefore be included in the *Berberido trigonae-Nothofagetalia dombeyi* order and, within this order, temporarily in the *Austrocedro-Nothofagion dombeyi* alliance, which comprises the most clearly sub-Mediterranean communities of the order. Nevertheless, a correct interpretation of the *lleuque* forests will require still more accurate research on the locations of the Chilean-Argentinian deciduous forests dominated by *robles*, from *Dioscoreo brachyobotryae-Nothofagetum obliquae*, described for the territory in Argentina, to *Elymo andini-Nothofagetum macrocarpae*, described for the Chilean sites of the region known as Libertador O'Higgins (parallel 34° south).

Appendix 2 shows some flora arrangements which we interpret as characteristic or territorial differentials of three phytosociological units whose profile in supratemperate Argentinian-Chilean territories is worth clarifying:

- + The first group shows the species which we consider as characteristic of continentalized, supratemperate Valdivian forests included in the *Berberido trigonae-Nothofagetalia dombeyi* order. Many of these species have previously been interpreted by Argentinian authors as belonging to the *Nothofagetea pumilionis-antarcticae*

class, although none of them were included as such by the author suggesting the syntaxa (OBERDORFER, 1960). To these we have also added some others which are more usually found in other syntaxa of the *Wintero-Nothofagetea* class, but whose presence in the *Berberido trigonae-Nothofagetalia dombeyi* forests can be used as a differential to highlight their non-inclusion in *Nothofagetea pumilionis-antarcticae*.

+ The second group is made up of scrub and microforest species representing scrub successional stages of the forests belonging to the above mentioned order. Although we support the name *Berberido-Nothofagetalia antarcticae* suggested by ESKUCHE (1969) for this unit, we think that some associations originally ascribed to this order are spurious. Ideally this order should be combined with those mantle scrubs and preforests defined for the temperate forests of Chile, that is, included in the *Aristotelienea chilensis* subclass. As occurs with the preceding case, some of the species chosen for this second group have their optimum in other orders belonging to that subclass. Consequently, their occurrence in the continental area must be interpreted as a differential species.

+ Finally, the third group comprises those species genuinely characteristic of the *Nothofagetea pumilionis-antarcticae* class, although some others, peculiar to the *Nothofagus pumilio* forests in the Magallanic Province, could also be added. In this third group, the proportion of species (almost 50%; those marked as +W-N) more or less frequently found in the supratemperate *Wintero-Nothofagetea* forests is particularly worth noting. Consequently, their role as characteristic species

must be interpreted as less significant. We think that the distinction *Nothofagetea pumilionis-antarcticae* versus *Wintero-Nothofagetea* must be identified with the limit between orotemperate versus supratemperate forests. To properly recognize this limit, the *Nothofagus pumilio* forests become particularly relevant for diagnostic purposes, given their role as bioindicators for the bioclimatic orotemperate belt, as suggested by AMIGO & al. (2007a).

CONCLUSIONS

Consequently, we propose the new forest association dominated by the *roble* (*Nothofagus obliqua*) and the *lleuque* (*Prumnopitys andina*). In the Chilean plant syntaxonomy this association must be included in the *Wintero-Nothofagetea* class. As a result, we also suggest subordinating to this phytosociological class some syntaxa interpreted in the 20th century by some Argentinian authors as belonging to the *Nothofagetea pumilionis-antarcticae* class.

ACKNOWLEDGMENTS

We would like to thank the staff of the Instituto de Botánica of the Austral University of Valdivia for their valuable help and support, Eduardo Castro Rodríguez for his photographic skills and assistance in field research, and the Xunta de Galicia and the University of Santiago for partially financing the time spent in Chile of one of the Spanish authors.

SYNTAXONOMICAL SCHEME OF THE MENTIONED COMMUNITIES

Wintero-Nothofagetea Oberd. 1960

Wintero-Nothofagetea Oberd. 1960

Laurelietalia philippiana Oberd. 1960

Nothofago-Eucryphion cordifoliae Oberd. 1960

Berberido trigonae-Nothofagetalia dombeyi Pollmann 2001

Myrceogenio-Nothofagion dombeyi (Eskuche 1999) Pollmann 2001

Dioscoreo brachyobotryae-Nothofagetum obliquae Eskuche (1973) 1999

Austrocedro-Nothofagion dombeyi Eskuche 1968

Nothofago obliquae-Prumnopitydetum andinae Amigo, Rodríguez-Gutián & Ramírez ass. nova

Elymo andini-Nothofagion obliquae Oberd. 1960 prov.
Elymo andini-Nothofagetum macrocarpae Oberd. 1960 prov. corr.

Aristotelienea chilensis Amigo, Ramírez & Quintanilla 2007
Aristotelietalia chilensis (Oberd. 1960) Hildebrand 1983
Berberidion buxifoliae Oberd. 1960
Azaro microphyllae-Aristotelietum chilensis Amigo, Ramírez & Quintanilla 2007
Berberido-Nothofagetalia antarcticae Eskuche 1969 (excl. *Discarietum articulatae*)

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Recibido: 3 septiembre 2009

Aceptado: 25 noviembre 2009

APPENDIX 2

Characteristic or differential species of the three Valdivian-Magallanic syntaxonomical units of Chile and Argentina.

<i>Berberido trigonae-Nothofagetalia dombeyi</i>		
<i>Anemone multifida</i> Poir.	<i>Cystopteris fragilis</i> (L.) Bernh.	<i>Myoschilos oblonga</i> Ruiz & Pavón (W-N)
<i>Austrocedrus chilensis</i> (D.Don) Pic.Ser. & Bizzarri	<i>Dioscorea brachybotrya</i> Poepp. (W-N)	<i>Polystichum plicatum</i> (Poepp. ex Kunze) Hicken
<i>Berberis trigona</i> Kunze ex Poepp.& Endl. (W-N)	<i>Elymus andinus</i> Trin.	<i>Relchela panicoides</i> Steud.
<i>Bowlesia tropaeolifolia</i> Gill. & Hook.	<i>Galium chilensis</i> Endl.	<i>Trisetum caudulatum</i> Trin.
<i>Calceolaria filicaulis</i> Clos	<i>Gavilea glandulifera</i> (Poepp.)Correa	<i>Vicia nigricans</i> Hook. & Arn.
<i>Carex patagonica</i> Spag.	<i>Gavilea odoratissima</i> Poepp.	<i>Viola maculata</i> Cav.
<i>Diplolepis descolei</i> (T.Mey.) Lieder & Rapini	<i>Maytenus chubutensis</i> (Spag.)Lourt., O'Don.& Sleum.	
<i>Berberido-Nothofagetalia antarcticae</i>		
<i>Azara microphylla</i> Hook.f. (+ Ach)	<i>Geranium patagonicum</i> Hook.f.	<i>Nothofagus antarctica</i> (G.Forster) Oerst. (+ Np-a)
<i>Berberis darwinii</i> Hook.	<i>Lomatia hirsuta</i> (Lam.) Diels ex J.F.Macbr. (+ Ach)	<i>Ovidia andina</i> (Poepp. & Endl.) Meisn.
<i>Berberis microphylla</i> G.Forst. (+ Ach)	<i>Maytenus boaria</i> Mol. (+ Ach)	<i>Relbunium hypocarpium</i> (L.) Hemsl.(+ Ach)
<i>Diostea juncea</i> (Gill. & Hook.) Miers	<i>Mutisia decurrens</i> Cav.	<i>Ribes cucullatum</i> Hook.et Arn. (+ Np-a)
<i>Festuca purpurascens</i> Banks & Sol. ex Hook.f.	<i>Mutisia spinosa</i> Ruiz & Pavón	<i>Ribes valdivianum</i> Phil. (+ Ach)
<i>Fragaria chiloensis</i> (L.)Duchesne	<i>Myrceugenia ovata</i> (Hook. & Arn.) Berg var. <i>nannophylla</i> (Burret) Landrum	<i>Schinus patagonicus</i> (Phil.) Johnst.

<i>Nothofagetea pumilionis-antarcticae</i>		
<i>Adenocaulon chilense</i> Less. (+W-N)	<i>Escallonia alpina</i> Poepp. ex DC.	<i>Ribes magellanicum</i> Poir. (+W-N)
<i>Alstroemeria aurea</i> Graham (+W-N)	<i>Gavilea lutea</i> (Pers.) M.N.Correa	<i>Ribes nitidissimum</i> Neger
<i>Anemone antucensis</i> Poepp.	<i>Hypochaeris tenuifolia</i> (Hook.& Arn.) Griseb.	<i>Rubus geoides</i> J.E.Sm. (+W-N)
<i>Arachnitis uniflora</i> Phil. (+W-N)	<i>Lagenophora hirsuta</i> Less. (+W-N)	<i>Senecio acanthifolius</i> Hombr. & Jacq.
<i>Araucaria araucana</i> K.Koch (+W-N)	<i>Leucheria thermanum</i> (Phil.) Phil.	<i>Senecio pilquensis</i> H.Buek
<i>Berberis montana</i> Gay (+W-N)	<i>Macrachaenium gracile</i> Hook. f.	<i>Senecio prenanthifolius</i> Phil.
<i>Berberis serrato-dentata</i> Lechler (+W-N)	<i>Maytenus disticha</i> (Hook.f.) Urban	<i>Uncinia negeri</i> Kuckenthal
<i>Cardamine glacialis</i> (G.Forster) DC.	<i>Nothofagus pumilio</i> (Poepp. & Endl.) Krasser (+W-N)	<i>Valeriana lapathifolia</i> Vahl (+W-N)
<i>Codonorchis lessonii</i> (Brongn.) Lindl.	<i>Perezia pedicularifolia</i> Less.	<i>Viola reichei</i> Skottsbo. ex Macloskie (+W-N)
<i>Drimys andina</i> (Reiche) R.A. Rodríguez & Quezada (+W-N)	<i>Perezia prenanthoides</i> Less.	
<i>Embothrium coccineum</i> J.R. Forster & G.Forster (+W-N)	<i>Ranunculus peduncularis</i> Sm.	

Top: continental, supratemperate, Valdivian-Magallanic forests (Chile and Argentina): *Berberido-trigonae-Nothofagetalia dombeyi*. The species which tend ideally to occur in other woodland communities belonging to different orders of the *Wintero-Nothofagetea* class are marked with (W-N).

Middle: continental scrub and microforests: *Berberido-Nothofagetalia antarcticae*. The species peculiar to other *Aristotelietales chilensis* communities and acting as differentials are marked with (Ach). Some cases marked with (+Np-a) are considered by other authors as characteristic of the *Nothofagetea pumilionis-antarcticae* class.

Below: orotemperate, Valdivian-Magallanic forests: *Nothofagetea pumilionis-antarcticae*. The species which are usually found in supratemperate *Wintero-Nothofagetea* forests are marked with (+W-N).