A VEGETATION MAP OF NEVADOS DE CHILLAN VOLCANIC COMPLEX, BIO-BIO REGION, CHILE

CARTOGRAFIA DE VEGETACION DEL COMPLEJO VOLCANICO NEVADOS DE CHILLAN, REGION DEL BIO-BIO, CHILE

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ABSTRACT

A vegetation survey of the Andean Nevados de Chillán volcanic complex, Bío-Bío Region, Chile, resulted in the preparation of a colour vegetation map, based on photo-interpretation of an aerial photograph of 1998. Classification followed a divisive method and combined physiognomic, floristic, and pedologic criteria. It resulted in eleven distinguishable vegetation units: (1) Nothofagus dombeyi forest, (2) N. pumilio forest, (3) Nothofagus mixed forest, (4) N. pumilio krummholz, (5) N. antarctica krummholz, assemblages of (6) Adesmia emarginata-Pozoa coriacea, (7) Adesmia emarginata-Berberis empetrifolia, (8) Adesmia emarginata-Loasa lateritia, (9) Chusquea culeou-Coirones, and (10) Caltha sagittata-Mimulus luteus, and the (11) Nassauvia revoluta-Poa obvallata assemblage which builds the upper vegetational belt. The study area’s vegetation, located in the Mediterranean-temperate transition zone, shows a higher floristic affinity to temperate regions’ vegetation.

KEYWORDS: Southern Andes, vegetation cartography, photo-interpretation, Termas de Chillán.

INTRODUCTION

The southern Andean volcanic complex Nevados de Chillán is situated at 36°50’S, 71°25’W, reaching a maximum elevation of 3212 m a.s.l. (Fig. 1). It is located in the transition zone between central Chile’s Mediterranean vegetation, constituted mainly of sclerophyllous elements, and the temperate evergreen forests of southern Chile (Grau 1995; Arroyo et al. 2004). The combination of biogeographic situation and geomorphologic complexity leads to an exceptional degree of botanical biodiversity. Nevados de Chillán harbours 616 species of 104 families (Rodríguez et al. 2008).
In this paper we aim to provide a large-scale color map of the spatial distribution of the vegetation of Nevados de Chillán’s southern sector based on the photo-interpretation of an aerial color photograph. Due to the high rate of economic development in this area, parts of its native vegetation are critically endangered. We hope that our map will aid conservation efforts and contribute to the discussion about the spatial distribution of vegetation patterns in the Mediterranean-temperate transition zone.

The study area of 87 km² comprises the south-western flanks of Nevados de Chillán, the surroundings of the thermal and touristic facilities of Termas de Chillán, Nieblas Valley, Aguas Calientes Valley, Shangri-La Valley, Cerro Purgatorio plateau, Los Coltrahues and the upper basin of the Renegado River. The vegetation limit is at 2700 m a.s.l. and the tree-line at 2100 m a.s.l.

Situated at the border between temperate and Mediterranean macrobioclimates at a latitude of 37°S (Luebert & Pliscoff 2006), the climate of Nevados de Chillán is cool-temperate, with dry summers and cold winters. Decker & Boerner (2003) gives an estimation of mean annual temperature of 4-6°C for the elevational range of 1200–1800 m. More than 75% of mean annual precipitation falls between April and September (Donoso 1993). Figure 2 shows temperature and precipitation data of Diguillín (Fig. 2A) and Laguna de La Laja (Fig. 2B) climate stations, which are situated 15 km and 70 km, respectively, to the south of Termas de Chillán (Luebert & Pliscoff 2006).

The volcanic activity of Nevados de Chillán complex dates back to at least 640 000 years ago. Two eruptive centers formed 40 000 years ago, building the summit structures Nevado and the twin volcanic cone Volcán Chillán, respectively (Dixon et al. 1999). González-Ferrán (1995) gives a detailed description of historic eruptions. The volcanic activity resulted in a manifold topography characterized by a complex relief and geology. The diversity of geologic substrates is mirrored by the high number of different vegetation units found. The soils of the study area developed from volcanic products and belong to the order inceptisols, suborder andept (Freiberg 1984).

Information about soils under Nothofagus pumilio forests can be obtained from Hildebrand-Vogel et al. (1990) and Decker & Boerner (2003).

Philippi (1862, 1892) and Reiche (1895, 1907) gave early reports of the area’s vegetation. Roivainen (1933) and Jaffuel (1938) published commented lists of collected plant specimens. Recent work includes the investigation of ecophysiological aspects of the study area’s Nothofagus forests (Decker & Boerner 2003; Fajardo & De Graaf 2004). A commented checklist of the vascular flora of Nevados is published by Rodríguez et al. (2008) in the same issue of this journal.

MATERIAL AND METHODS

From August 2005 to April 2006 eight field trips to Nevados de Chillán were carried out. Data of 506 waypoint sites include geographic location, elevation, aspect, vegetation physiognomy, and observations on soil condition and disturbance. Floristic information of waypoint site vegetation was obtained by recording plant species composition. The vegetation units were classified by a divisive method (Goldsmith & Harrison 1976), employing a synthesis of physiognomy (life form, structure and...
Spacing) and floristics as dividing characters to subdivide major physiognomic classes into successively smaller unites (Küchler & Zonneveld 1988, Fosberg 1967). Soil features like colour and site drainage were also taken into account.

The physiognomy, i.e. the physical appearance, of vegetation is a combination of structural and functional characters (Fosberg 1967). Whereas structure describes the spatial arrangement of the individual plants that build the vegetation, function refers to characters that fulfill purposes of maintaining life functions in a certain environment (Barbour et al. 1987). Functional characters are, for example, related to fire resistance or drought tolerance.

Classification and mapping of vegetation by applying purely physiognomic characteristics can be performed without much effort using air-photos (Goldsmith & Harrison 1976), but does not always satisfy the need for more detailed studies as it is suitable mainly for large areas and floristic information is lost. This generates a problem particularly in the vegetation analysis of andine enviroments (Cavieres et al. 2000).

Combining physiognomic, floristic, and, subordinately, pedologic criteria to classify vegetation allows a compromise between a reasonable number of distinguishable vegetation units and a useful map scale. Our map is based on photo-interpretation of an aerial colour orthophotograph of 1998, with a 4 m resolution, which was provided by Centro EULA, University of Concepción. Comparison with satellite images of December 2002 and May 2003 did not show any recognizable change of vegetation cover.

Interpretation of the photographic material, supported by the field data, led to the identification of the major physiognomic classes on the base of vegetation architecture and life form. These major classes correspond to closed woodland of phanerophytes (growth height > 2 m) and lower vegetation of the Andean belt consisting of nanophanerophytic (growth height < 2 m), chamaephytic, hemicyryptophytic, cryptophytic, and therophytic plants (see Raunkiaer 1934 for life-form descriptions). We then proceeded by dividing these major categories into smaller structural subunits. Thus, closed woodland was separated into the subunits forest and krummholz; Andean belt vegetation into the subunits scrub/dwarf scrub of open spacing between individual plants and closed wet meadows. In a third step we employed floristic, and, with regards to the three floristically similar Adesmia emarginata-dominated assemblages, also pedologic criteria in the

![Figure 2. Climate data from Diguillín (A) and Laguna de La Laja (B) weather stations, from Luebert & Pliscoff (2006).](image)
form of soil colour, field texture, and stone quantity to define the resulting eleven vegetation units.

The amount of the area that is directly or indirectly concerned by human activities was quantified on the base of photo-interpretation and the use of photographs and field notes made during the field trips. The geographical information system software ArcView GIS 3.2 and ArcMap 9.0 were used for data processing and management as well as for map drawing. The collected plant specimens were deposited in the herbarium of the University of Concepción, Chile (CONC).

**RESULTS**

Photo-interpretation resulted in thirteen cartographic units (Table I, Fig. 3). Eleven of them are proper vegetation units, i.e. with vascular plant cover. They can be divided into two physiognomically different major classes: closed woodland and Andean vegetation above tree-line.

Woodland assemblages comprise (1) *Nothofagus dombeyi* forest, (2) *Nothofagus pumilio* forest, (3) *Nothofagus* mixed forest, (4) *Nothofagus pumilio* krummholz, and (5) *Nothofagus antarctica* krummholz.

The three floristically related *Adesmia emarginata*-dominated assemblages of (6) *Adesmia emarginata-Poa coriacea*, (7) *Adesmia emarginata-Berberis empetrifolia*, and (8) *Adesmia emarginata-Loasa lateritia*, as well as the vegetation units of (9) *Chusquea culeou-Coirones*, (10) *Caltha sagittata-Mimulus luteus*, and (11) *Nassauvia revoluta-Poa obvallata* build the Andean vegetation.

The vegetation map also includes the cartographic units (12) Cortina Lava, and (13) rocks and ice. These bear none to very little vascular plant cover.

The vegetation units are now described in detail. Nomenclature follows Marticorena & Quezada (1985). Representative photographs of each vegetation unit are included in Pfanzelt (2007).

<table>
<thead>
<tr>
<th>CARTOGRAPHIC UNIT</th>
<th>AREA IN HA</th>
<th>AREA IN %</th>
<th>ELEVATION IN M A.S.L.</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Nothofagus dombeyi</em> forest</td>
<td>360</td>
<td>4.2</td>
<td>1200-1900</td>
</tr>
<tr>
<td><em>Nothofagus pumilio</em> forest</td>
<td>1370</td>
<td>15.8</td>
<td>1420-1860</td>
</tr>
<tr>
<td><em>Nothofagus</em> mixed forest</td>
<td>1020</td>
<td>11.8</td>
<td>1200-1820</td>
</tr>
<tr>
<td><em>Nothofagus pumilio</em> krummholz</td>
<td>720</td>
<td>8.3</td>
<td>1520-2050</td>
</tr>
<tr>
<td><em>Nothofagus antarctica</em> krummholz</td>
<td>250</td>
<td>2.9</td>
<td>1200-2100</td>
</tr>
<tr>
<td><em>Adesmia-Poa assemblage</em></td>
<td>220</td>
<td>2.5</td>
<td>1530-2110</td>
</tr>
<tr>
<td><em>Adesmia-Berberis</em> assemblage</td>
<td>750</td>
<td>8.7</td>
<td>1860-2230</td>
</tr>
<tr>
<td><em>Adesmia-Loasa</em> assemblage</td>
<td>290</td>
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<td>1760-2310</td>
</tr>
<tr>
<td><em>Chusquea-Coirones</em> assemblage</td>
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<td>6.3</td>
<td>1330-2020</td>
</tr>
<tr>
<td><em>Caltha-Mimulus</em> assemblage</td>
<td>70</td>
<td>0.8</td>
<td>1640-2400</td>
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<td><em>Nassauvia-Poa</em> assemblage</td>
<td>1570</td>
<td>18.1</td>
<td>2120-2700</td>
</tr>
<tr>
<td>Cortina Lava</td>
<td>700</td>
<td>8.1</td>
<td>-</td>
</tr>
<tr>
<td>Rocks, ice, and eroded areas</td>
<td>800</td>
<td>9.2</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8670</strong></td>
<td><strong>100.0</strong></td>
<td><strong>1200-2700</strong></td>
</tr>
</tbody>
</table>
FIGURE 3. Vegetation map of Nevados de Chillán.

Vegetation units

- (1) Ceramic Lava
- (2) Ceniza Lava
- (3) Basaltic-Rhyolitic Association
- (4) Basaltic-Rhyolitic Association
- (5) Basaltic-Rhyolitic Association
- (6) Basaltic-Rhyolitic Association
- (7) Basaltic-Rhyolitic Association
- (8) Basaltic-Rhyolitic Association
- (9) Basaltic-Rhyolitic Association
- (10) Basaltic-Rhyolitic Association
- (11) Basaltic-Rhyolitic Association
- (12) Basaltic-Rhyolitic Association
- (13) Rocks and Ice

A vegetation map of Nevados de Chillán: PFANZELT, S. et al.
WOODLAND ASSEMBLAGES

(1) Nothofagus dombei forest
Elevation: 1200-1900 m a.s.l.; all aspects.
Description: Preferring humid localities along the riverbeds of Shangri-La Valley and the lower Renegado River, evergreen N. dombei (Mirb.) Oerst. builds old-growth forests. Trunks and branches of the tree species are covered by Usnea lichens. A dense understory is composed of bamboo Chusquea culeou E.Desv. and Gaultheria sp. The herbaceous layer is dominated by Osmorhiza berteroi DC., Alstroemeria aurea Graham and Loasa acanthifolia Desr.


(2) Nothofagus pumilio forest
Elevation: 1420-1860 m a.s.l.; all aspects.
Description: Deciduous forest of Nothofagus pumilio prevails at higher altitudes and at drier sites. Its vertical stratification is less diverse than that of its N. dombei counterpart. Nothofagus pumilio forest covers the Cerro Purgatorio plateau and the lower Nieblas Valley. Understory species composition does not differ substantially from that of N. dombei but includes Viola reichei Skottsbt., the orchid Codonorchis lessoni (d’Urv.) Lindl., as well as local abundant Berberis rotundifolia Poepp. et Endl. Common fungi are Guepinopsis alpina (Tracy et Earle) Brasf., Phellinus andinopatagonicus (Wright et Desch.) Ryv., and Hypholoma frowardii (Spec.) Horak.


(3) Nothofagus mixed forest
Elevation: 1200-1820 m a.s.l.; aspect: N, NW of N. obliqua-dominated stands.
Description: The proportion of the three Nothofagus species N. dombei, N. pumilio, and N. obliqua varies in the Nothofagus mixed forest, according to moisture availability, soil, altitude, and exposure. Whereas pure N. obliqua stands prefer warm, N-exposed slopes, N. pumilio outcompetes N. dombei and N. obliqua at cold sites and higher elevations. Almost pure stands of mature Nothofagus obliqua forest with a closed canopy can be found on the lower slopes of Los Coltrahues and Cerro Las Cabras. Associated with them are shrubs like Berberis microphylla G.Forst., Maytenus disticha, and Ribes sp., and herbs like Alstroemeria aurea. Open Nothofagus mixed forest of Shangri-La Valley differs in spacing between individuals from the one of the locations mentioned above. On very dry, gray soils derived from volcanic sands N. pumilio and N. obliqua form an open forest with a sparse ground cover of so-called coirones (Festuca sp.) and the cactus Maihuenia poeppigii (Otto ex Pfeiff.) K.Schum.


(4) Nothofagus pumilio krummholz
Elevation: 1520-2050 m a.s.l.; all aspects.
Description: At elevations of 1600 to 1800 m a.s.l. the Nothofagus pumilio forest gives way to a dense krummholz of up to six meter height, composed of the same species. The mechanical forces of wind pressure and invernal snow load causes N. pumilio to assume a bent and twisted growth form. Chusquea culeou and Maytenus disticha develop below the closed canopy, Adesmia emarginata Clos, Quinchemalium chilense Molina, and Sisyrrhinium arenarium Poepp. grow within clearings and along footpaths. On rocky outcrops in between N. pumilio krummholz of upper Cerro Purgatorio Orites...
myrtoidea (Poepp. et Endl.) Benth. et Hook. f. ex B.D.Jacks. can be found.


(5) *Nothofagus antarctica* krummholz

**Elevation:** 1200-1820 m a.s.l.; aspects at elevations above 1800 m a.s.l.: N, NE, SW.

**Description:** Structurally very similar appears the study area’s second krummholz assemblage, dominated by *N. antarctica*. This highly cold-resistant species grows in high density on the dry, fast draining soils of Las Trancas and the vicinity of Refugio Aserradero. Further krummholz patches, just two meters high, cover small areas of Aguas Calientes Valley’s northwestern slopes at 2100 m a.s.l., and of the northern slopes of Los Coltrahues. Frequently, *Mutisia decurrens* Cav. climbs upon the branches of *N. antarctica*.

**Species composition:** *Berberis empetrifolia*, *Chusquea culeou*, *Festuca sp.*, *Gaultheria pumila*, *Mutisia decurrens*, *Nothofagus antarctica*, *N. pumilio*.

**Assemblages of the Andean Belt**

Dominance of the ubiquitous shrub *Adesmia emarginata* already indicates the floristic similarity of assemblages (6) to (8), which share common species like *Viola cotyledon*, *Euphorbia portulacoides*, and *Acaena leptacantha* Phil. as well. Nonetheless, soil conditions like colour, field texture, stone quantity, and bedrock geology differ.

(6) *Adesmia emarginata- Poza coriacea* assemblage

**Elevation:** 1530-2100 m a.s.l.; aspect: S, SW, W, NW; soil: gray to black, sandy, dry.

**Description:** This azonal vegetation unit with a low degree of coverage grows on alluvial, fast draining soils. It reaches noteworthy extensions near Garganta del Diablo, at the satellite cone Parador and on the alluvial plains north of Cortina Lava.


(7) *Adesmia emarginata-Berberis empetrifolia* assemblage

**Elevation:** 1860-2230 m a.s.l.; aspect: SW, W; soil: grayish-black, sandy, mixed with lava boulders.

**Description:** Occupying dacitic lava block landscape, this floristically diverse assemblage is dominated by *Adesmia emarginata*. Important differential species are *Berberis empetrifolia* and *Blechnum microphyllum* (Goldm.) C.V.Morton. At higher altitudes species number decreases and —marking the gradual transition into the *Nassauvia revoluta-Poa obvallata* assemblage— *Nassauvia revoluta* D.Don and *Chaetanthera villosa* D.Don appear.


(8) *Adesmia emarginata-Loasa lateritia* assemblage

**Elevation:** 1760-2310 m a.s.l.; all aspects except E; soil: brown, ochre, stony.

**Description:** The *Adesmia-Loasa* scree vegetation occupies the altitudinal belt from 1750 to 2300 m a.s.l. of the upper slopes of Nieblas Valley and Cerro Pirigallo. Soil physiognomy differs substantially from the one of the *Adesmia-Berberis* assemblage and is the main reason for separating these units. The dominant species is *Adesmia emarginata*. Less frequent, but nonetheless of high differential character are *Loasa lateritia* Gillies ex Arn. and *Schizanthus hookeri* Gillies ex Graham. *Festuca magellanica* and *F. therarum* are abundant on sites where wind-accumulated sands build a finer soil substrate.

**Species composition:** *Acaena leptacantha*, *Adesmia emarginata*, *Berberis empetrifolia*, *Loasa lateritia*, *Viola cotyledon*.

(9) Chusquea culeou-Coirones assemblage
Elevation: 1330-2020 m a.s.l.; aspect: predominantly N; soil: brown, sandy at higher elevations; lighter coloured and coarser texture at lower elevations.
Description: The sun exposed north-facing slopes of Los Coltrahuces and Cerro Las Cabras are covered by this assemblage. Dominant representatives are Chusquea culeou and elements of gramineous vegetation like Festuca sp. and Poa sp. Therefore, the vegetation cover of the gently sloped Los Coltrahuces ridge shows the appearance of a typical Andean grassland community. Important components of steep and rocky slope vegetation are Eryngium paniculatum Cav. et Dombey ex F.Delaroche and Puya alpestris (Poepp.) Gay. Both reach altitudes of 1800 m a.s.l.


(10) Caltha sagitata-Mimulus luteus assemblage
Elevation: 1640-2400 m a.s.l.; all aspects; soil: black, peaty, high organic content.
Description: This azonal, hygrophyllous vegetation unit depends on the availability of surface moisture that is provided by small streams of melt water. Most important species are Caltha sagitata Cav., Mimulus luteus L., and Ranunculus peduncularis Sm. Dominant gramineous representatives are Carex decidua Boott and Marsippospermum grandiflorum (L.f.) Hook.f. An interesting element of this assemblage is Chillania pusilla Roiv., which is endemic to Bio-Bio Region.

(11) Nassauvia revoluta-Poa obvallata assemblage
Elevation: 2120-2700 m a.s.l.; all aspects.
Description: The upper altitudinal vegetational belt consists mainly of a sparse plant cover dominated by Nassauvia revoluta and Poa obvallata E.Desv., which grow on gravel and scree slopes and between lava rocks. Senecio portalesianus J.Remy and Chaetanthera villosa reach altitudes of 2500 m a.s.l.
(12) Cortina Lava
The northern sector of the study area is covered by a postglacial dacitic lava flow, the so-called Cortina Lava, which reaches the upper Shangri-La Valley. Soil development is prohibited by the lava flow’s structure. As huge rocks are piled up with plenty of empty room between them, sediments do not accumulate. So Cortina Lava is devoid of vegetation, apart from a few individuals of Festuca sp., Poa sp., and—at lower altitudes—Orites myrtoidea.

(13) Rocks, ice and eroded areas
Rocks, ice and eroded areas bare of vascular plant cover are summarized cartographically as one category.

HUMAN INFLUENCE
Direct or indirect human activity exercises its influence on 30 km² of the study area.

The Cerro Purgatorio forest stands, as well as the north-facing slopes of Cerro Torrealba are used as seasonal pasture for domestic animals like cattle and horses. Grazing and trampling impedes natural forest rejuvenation and promotes soil erosion and loss of biodiversity. At Cerro Torrealba grazing-resistant species like Rumex acetosella and Acaena leptacantha are substantially more frequent than at undisturbed sites.

Skiing affects the south-western slopes of Volcán Chillán. Especially cushion plants like Nassauvia sp. suffer damage (Freiberg 1985). For ski runs and service roads, terrain was mechanically graded and forest was cut. As a consequence, plant species composition may change, and vegetation cover and diversity may decrease (Wipf et al. 2005).

Touristic activities and construction of summer cabins lead to disturbances in the surroundings of Termas de Chillán resort, in the lower Shangri-La Valley, and the Las Trancas sector, putting old-growth Nothofagus forest in danger.

At Valle Hermoso the alien conifer species Pseudotsuga menziesii (Mirb.) Franco was planted, altering the species composition of native forests. The invasive species Verbascum thapsus L. and Hypericum perforatum, both of European provenance, already reach altitudes of 2000 and 1800 m a.s.l., respectively.

DISCUSSION
In this chapter we discuss our results in the context of Nevados de Chillán’s location in the Mediterranean-temperate transition zone. Besides, we comment on conservation issues.

BIOGEOGRAPHY
Luebert & Pliscoff (2006) describe the transitional vegetation unit “Bosque caducifolio mediterráneo-templado andino de Nothofagus pumilio y N. obliqua”. Its floristic composition corresponds very well to the Nothofagus pumilio forests found in the study area. The occurrence of Berberis rotundifolia and N. obliqua with distribution ranges from 35°-39°S (Landrum 2003) and 33°-41°S (Rodríguez & Quezada 2003), respectively, indicates the transitional character of Nothofagus mixed forests as well. According to Donoso (1993), Nevados de Chillán is located near the northern distribution limit of Nothofagus pumilio (lenga) forest type (Tipo forestal Lenga, subtipo de Bosque de Lenga puro) which supports a more temperate character of the study area’s Nothofagus pumilio forests. However, Andean Nothofagus pumilio forests further south feature a Drimys andina (Reiche) R.A.Rodr. et Quez. understory (Hildebrand-Vogel et al. 1990), which is completely missing from N. pumilio forests of the study area.

Other woodland assemblages as well show temperate affinities: Gajardo (1994) places Nothofagus krummholz into the the sub-region “Bosque Caducifolio Alto-Andino de Chillán” of an Andean-patagonian category called “Región del Bosque Andino-Patagónico”.

Nothofagus dombeyi forest stands of Nevados de Chillán are restricted to sites along water courses. Laurophyllous elements are missing. Therefore, this woodland assemblage should be regarded as azonal vegetation without a strong biogeographical connection to the temperate evergreen rainforests south of 40°S, where N. dombeyi forms an important element.

Prominent constituents of Andean-Mediterranean forests north of 35°S, e.g. Austrocedrus chilensis (D. Don) Pic.Serm. et Bizzarri, Kageneckia angustifolia D.Don, Quillaja saponaria Molina, and Lithrea caustica (Molina) Hook. et Arn. (Arroyo et al. 2004), are absent from the study area itself.
According to Luebert & Pliscoff (2006), “Matorral bajo templado andino de Discaria chacayae y Berberis empetrifolia” builds the Andean vegetation belt in Bio-Bío and Araucania Regions. It corresponds to Gajardo’s (1994) formation “Estepa Alto-Andina Sub-Húmeda”. Both categories rank as temperate ones. Their floristic composition descriptions, although very general, fit well with the vegetation actually found in study area’s Andean belt vegetation. Furthermore, typical cushion plants of Chile’s Central Andes like Laretia acaulis (Cav.) Gillies ex Hook., Azorella madreporica Clos, and A. monantha Clos where not found in the study area. Two elements of the Andean belt’s Caltha-Mimulus unit, Calta appendiculata and Marsippospermum grandiflorum, are regarded by Freiberg (1985) to represent link species to Antarctic peat bog communities.

In summary, temperate biogeographical features prevail in the study area.

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