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Woodland communities in the Chilean cold-temperate zone (Baker and Pascua basins): Floristic composition and morpho-ecological transition

Comunidades leñosas en la zona chilena frío-templada (cuencas de los ríos Baker y Pascua): Composición florística y transición morfo-ecológica

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ABSTRACT

This study describes the floristic composition and morpho-ecological transition of woodlands along a climatic gradient in the southern cold temperate zone of Chilean Patagonia. A total of 256 phytosociological relevés were performed across a 150 km NE-SW transect to record vascular plant species. Classification (cluster analysis) and ordination (principal component analysis) techniques were used to segregate and examine the communities. Biodiversity indicators including richness and abundances of species natives and exotics, importance values, Raunkiaer plant life-forms, diversity indices and indicator species were calculated to describe community attributes. Beta diversity was analysed using the Jaccard index. Additionally, the current anthropogenic disturbances affecting this vegetation are discussed. In total, 11 woodland communities belonging to 3 morpho-ecological groups were segregated: a) meso-hygromorphic woodlands belonging to the Baker basin, mostly composed of deciduous forests containing relatively moderate values of richness and diversity but high richness of exotics, b) hygromorphic woodlands belonging to the southern segment of the Baker basin and along the Pascua basin, composed of evergreen forest containing the relatively highest values of richness and diversity and very low richness of exotics and c) high-Andean dwarf woodlands distributed at high elevations in both basins, composed of deciduous krummholz containing the lowest richness and diversity and no exotics. The replacement of deciduous by evergreen communities at low elevations occurs around the latitude 48°S. Anthropogenic disturbances like logging by rural landowners, overgrazing by livestock and road construction are promoting biological invasions in the Baker basin forests, while the forests in the Pascua basin remain pristine since no human population occurs there.

KEYWORDS: Biogeographical transition, southern cold temperate zone, anthropogenic disturbances, pristine forests, Aysén.

RESUMEN

Este estudio describe la composición florística y la transición morfo-ecológica de las comunidades leñosas ocurriendo a través de un gradiente climático en la zona templada fría de la Patagonia chilena. Se establecieron un total de 256 relevamientos fitosociológicos a través de un transecto NE-SO de 150 km para registrar las especies de plantas vasculares. Técnicas de clasificación (análisis de conglomerados) y ordenación (análisis de componentes principales) fueron usadas para segregar y examinar comunidades. Se computaron indicadores de biodiversidad incluyendo riqueza y abundancia de especies nativas y exóticas, valores de importancia, formas de vida de Raunkiaer, índices de diversidad y especies indicadoras para describir atributos comunitarios. La diversidad Beta fue analizada usando el coeficiente de Jaccard. Se discuten también las perturbaciones antropogénicas que actualmente afectan a la vegetación. En total se segregaron 11 comunidades pertenecientes a tres grupos ecológicos: a) comunidades leñosas meso-higromórficas pertenecientes a la cuenca del Baker, conformada principalmente de bosques caducifolios conteniendo valores relativos intermedios de riqueza y diversidad, pero las mayores riquezas de exóticas; b) comunidades leñosas higromórficas pertenecientes al segmento sur de la cuenca del río Baker y a través de toda la cuenca del río Pascua, compuesta de bosques siempreverdes conteniendo los mayores valores de riqueza y diversidad y muy baja riqueza de exóticas, y c) comunidades leñosas achaparradas altoandinas, distribuidas en lugares de alta elevación en ambas cuencas, compuestas de krummholz conteniendo la menor riqueza y diversidad, sin presencia de especies introducidas. El reemplazo de comunidades caduficolias por siempreverdes en sentido norte-sur sucede alrededor de la latitud 48°S. Perturbaciones antrópicas como la tala de madera por propietarios rurales, sobrepastoreo por ganado doméstico y ampliaciones en los caminos, están provocando invasiones biológicas en los bosques de la cuenca del río Baker, mientras que los bosques de la cuenca del río Pascua, donde no ocurre poblamiento humano, permanecen prístinos.

Palabras clave: Transición biogeográfica, zona templada fría, perturbaciones antrópicas, bosques prístinos, Aysén.

INTRODUCTION

The Baker and Pascua rivers are located in the Aysén Region in northern Chilean Patagonia. The former is about 175 km in length, originating at the southern tip of Bertrán Lake and ending in the Baker Channel. The Pascua River, in turn, is 67 km in length, originating at the northwest side of O'Higgins Lake and ending at the Calén Fjord. Adjacent to both rivers is an extensive 150 km long basin-strip system, distributed along a steep precipitation gradient with annual precipitation ranging from approximately 350 mm in the continental areas to 3,000 mm at the archipelagic locations (Amigo & Ramírez 1998). These basins are flanked to the northwest by the North Patagonian Ice Fields and to the southwest by the archipelagic zone. The entire area is transected by the Andean mountain range, with elevations ranging from sea level to 1,200 m. The area is thus a tangled corridor where floristic elements transit latitudinally and altitudinally throughout the "Southern Cold Temperate Zone" (Du Rietz 1960, Holdgate 1960) (Fig. 1). The vegetation in this area is diverse and includes Patagonian steppes, shrublands, deciduous forests, perennial forests at low elevations and moorland vegetation above the timberline (e.g. Hueck 1978, Veblen & Schlegel 1982, Luebert & Pliscoff 2006). Given the difficult access to some parts of the region and its low human population density (0.8 inhabitants per km^2), the region contains landscapes in completely pristine conditions (Martínez-Harms & Gajardo 1998).

The first descriptions of the area's vegetation correspond to phytogeographical studies made at the beginning of the 20th century by Reiche (1934) and Hambleton (1936), who described the forest vegetation and drafted some geographical limits. Hambleton (1936) mentioned the forests dominated by *Nothofagus dombeyi* (Mirb.) Oerst distributed in the northern area of the Baker basin. Reiche (1934), meanwhile, mentioned the *Nothofagus pumilio* (Poepp. et Endl.) Krasser forests in the central area of the Baker basin and the presence of steppe-like shrublands in the northeastern area. He described forests in the southern area as being dominated by *Nothofagus nitida* (Phil.) Krasser and krummholz communities and 'carpet vegetation' above the timberline. Godley (1960) established latitude 48°S as the limit where deciduous forests are replaced by perennial forests and subantarctic moorlands.

Although later studies have described and delineated the woodland vegetation of the area (e.g. Fuenzalida & Pisano 1967, Pisano 1972, Hueck 1978, Veblen & Schlegel 1982, Luebert & Pliscoff 2006), none have been able to fully compile its complex structure and diversity, partly due to the difficult access of some of these places. Moreover, some of the authors considered just dominant species, omitting valuable information related to target non-dominant ones. Detailed information can be not only interesting for biogeographers looking to explain biotic patterns, but also useful for managers requiring quantified information to take management decisions (Noss 1990). In this context, this study aimed: 1) to classify and describe the woodland communities along the Baker and Pascua river basins, 2) to compare the floristic diversity among these communities, 3) to delineate the distribution of native woodland communities and 4) to describe human disturbances affecting this vegetation.

MATERIALS AND METHODS

Study area

The study was carried out in the Baker and Pascua basins, located in the administrative Region of Aysén in northern Chilean Patagonia (Fig. 1). This area (~150,000 ha) lies approximately between 47°03'S and 48°21'S and 73°19' W and 72°27' W. The altitudinal range is from sea level to ~1,200 m. Meteorological data from the study area are not available, but a notable NE-SW climatic gradient can be observed. Annual temperatures recorded at the nearest meteorological stations range from 10°C (Chile Chico, 46º36'S - 71º43'W) to 7.1ºC (Puerto Edén, 49º08' S - 74º25'W), while precipitation ranges from 355 mm (Chile Chico) to 3,033 mm (Puerto Edén). These two locations belong to the dry and ultraperhumid bioclimatic belts, respectively, in the temperate zone of Chile (Amigo & Ramírez 1998). The vegetation in the study area includes arid steppes, xerophylous shrublands and deciduous forests in NE locations, being gradually replaced toward the SW by hygrophilous vegetation such as peatlands, shrublands, and perennial forests (Luebert & Pliscoff 2006).

Field methods and taxonomical determinations

Between April 2006 and March 2007, four field expeditions were organized in order to cover the entire ~150 km NE-SW transect in the study area. Sample sites were selected according to a stratified design using aerial photographs and were accessed by means of horses, vehicles, boats and helicopters because of the difficulty of the terrain.

In each site a 500 m^2 phytosociological relevé (Mueller-Dombois & Ellenberg 1974) was delimited to record all vascular plants and to estimate the percentage of abundances of each. Topographical features such as elevation, slope inclination, slope aspect and GPS location were also recorded. Voucher specimens were collected and determined using taxonomical literature (Cabrera 1949, Muñoz-Schick 1980, Moore 1982, Matthei 1995, Ruiz 2001, Landrum 2003, Rodríguez & Quezada 2003, Marticorena 2006). Nomenclature follows Henríquez *et al.* (1995) and Rodríguez *et al*. (2008).

DATA ANALYSIS

We constructed a relevé-by-species abundance matrix containing a total of 256 relevés and 201 species. Species abundance data were transformed by using the logarithmic transformation (log (x+1)) to get an approximation close to normal and to stabilize the variance (McCune & Grace 2002), as required for multivariate methods. In order to detect plant communities, the relevé-by-species abundance matrix was classified by performing hierarchical agglomerative clustering using Ward's minimum variance criterion (Euclidean distance) to minimize the increase in within-group variance (Hammer *et al.* 2001). Sites belonging to a particular cluster-group (i.e. community) were pooled and the new community-by-species matrix was ordinated using principal component analysis (PCA) (Euclidean distance) to examine the structure of nodal communities. From each community-by-species matrix the structural and compositional attributes of vegetation biodiversity were extracted (Noss 1990), i.e. mean species richness, cumulative abundances, importance values (Wikum & Shanholtzer 1978), diversity indices (Shannon and Berger-Parker, Moreno 2001), Raunkiaer plant life-forms (Mueller-Dombois & Ellenberg 1974) and exotic-native species ratio (Noss 1990). Indicator species analysis (Dufrêne & Legendre 1997) was performed to assess fidelity of particular species to each community as diagnostic species. In order to compare diversity between communities, a beta diversity comparison matrix using the Jaccard coefficient (Lapin & Barnes 1995) was performed from the pooled database. Finally the patterns of biological invasions were explored by evaluating correlation between elevation of sites, distance to roads and number of exotic plant species. Structural and compositional attributes of communities, cluster analysis, PCA and correlations were performed using the PAST statistical package version 1.91 (Hammer *et al.* 2001). ISA was performed using the labdsv indval Package for R statistical software.

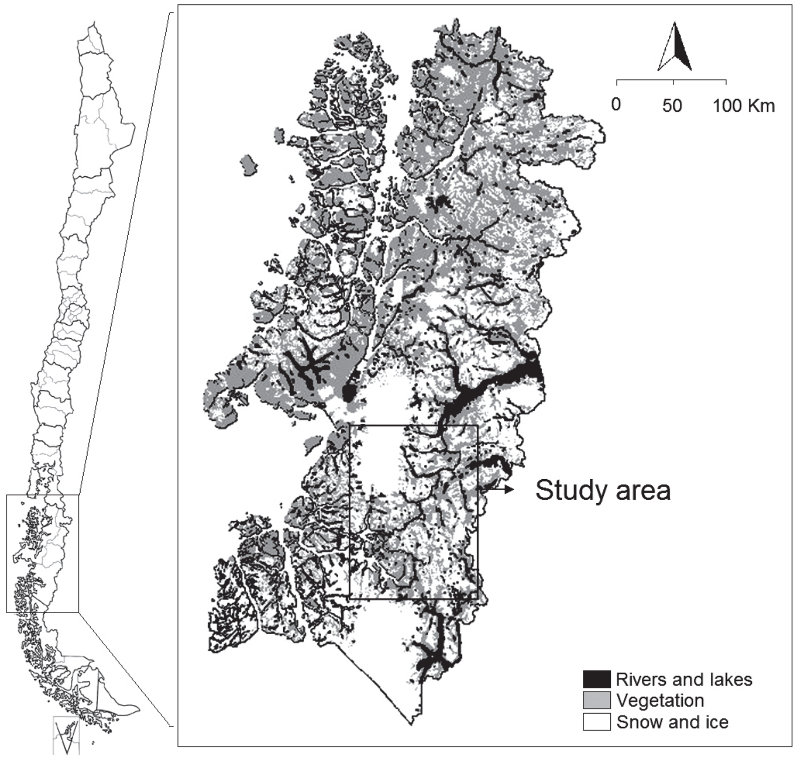

FIGURE 1. Map of Aysén, northern Chilean Patagonia, showing the study area.

FIGURA 1. Mapa de Aysén, Norte de Patagonia Chilena, mostrando el área de estudio.

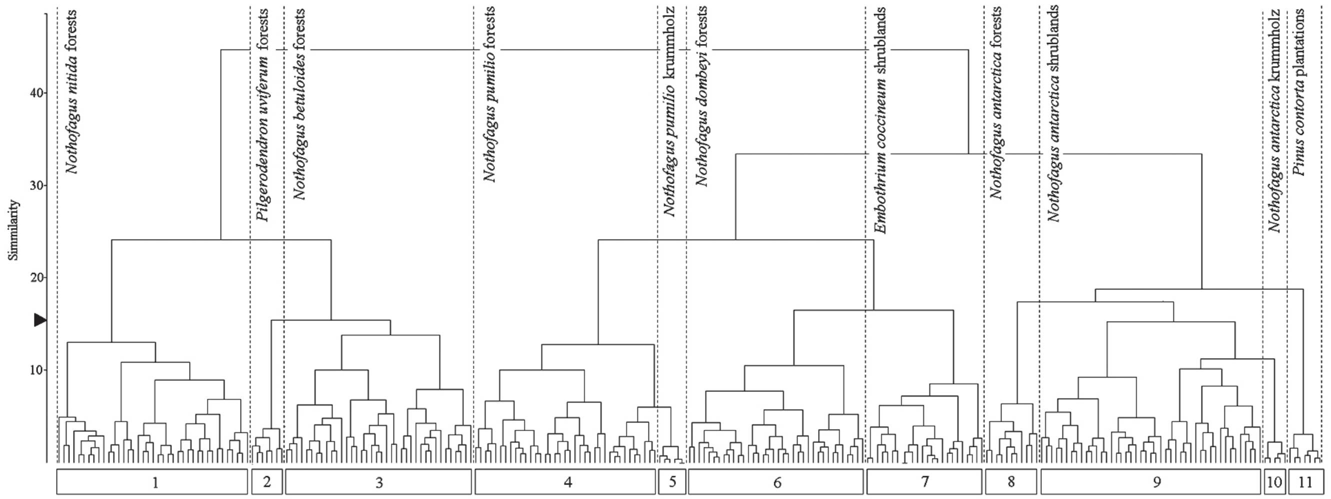

Figure 2. Dendrogram showing floristic relationships among the communities segregated in the present study. The arrow on the *y*-axis indicates the segregation point. Communities 5 and 10 were arbitrarily segregated (see results section).

Figura 2. Dendrograma mostrando las relaciones florísticas entre las comunidades segregadas en el presente estudio. La flecha en el eje *y* muestra el punto de segregación. Las comunidades 5 y 10 fueron segregadas arbitrariamente (ver la sección de resultados).

RESULTS

Classification, ordination and description of communities

Nine woodland communities were classified after clustering (Fig. 2), but 2 sub-groups, krummholz dominated by *Nothofagus pumilio* (5 relevés) and krummholz dominated by *Nothofagus antarctica* (G.Forst.) Oerst. (5 relevés), were arbitrarily reassigned as communities based on their habitat features (lower canopy heights), lower number of species and site topography (high elevation sites, steep slopes).

The ordination diagram (Fig. 3) showed the nodal communities distributed in 3 groups along the two principal components, explaining 53.8% of the variance. These components can be hypothesized as environmental factors affecting the distribution of plant communities. We thus hypothesized that component 1 (x-axis) was temperature and component 2 (y-axis) was precipitation. The first group contained 3 communities distributed in colder and more humid places and included forests dominated by *Nothofagus betuloides* (Mirbel) Oersted, forests dominated by *Nothofagus nitida* and forests dominated by *Pilgerodendron uviferum* (D.Don) Florin. The second group contained 5 communities distributed in warmer places with intermediate levels of precipitation and included *Nothofagus antarctica* forests, *Embothrium coccineum* shrublands, *Nothofagus antarctica* shrublands*, Nothofagus dombeyi* forests and *Nothofagus pumilio* forests. The third group of communities can be considered to be distributed in dry and cold places and included krummholz dominated by *Nothofagus antarctica* and krummholz dominated by *Nothofagus pumilio*. A brief description of the plant communities is provided below, based on dominant species, importance values (IV), diagnostic species identified by indicator species analysis (ISV) (Annex 1), plant life-forms (Fig. 4), and cumulative richness of native and exotic species. Communities were named according to the dominant species, but a phytosociological name from the literature was also provided:

1) ***Nothofagus nitida* forests** (*Luzuriago polyphyllae-Nothofagetum nitidae*). Evergreen and multi-layered forests located mainly in lowland and flat areas (0 - 400 m) close to river courses and lakes. Trees reach up to a height of 30 m. The vegetation structure is complex, dominated in the upper layer by *Nothofagus nitida* (IV 32.2) but co-dominated by other phanerophytes like *Podocarpus nubigena* Lindl. (IV 18.7), *Drimys winteri* J.R.Forst. et G.Forst. (IV 16.5) and *Desfontainia fulgens* D.Don (IV 3.7), among others. There is a notable presence of plants growing as epiphytes, including *Hymenophyllum krauseanum* Phil. (IV 18.5), *Philesia magellanica* J.F.Gmel. (IV 5.3) and *Mitraria coccinea* Cav. (IV 5.0). The shrub layer is also rich, containing microphanerophytes like *Pseudopanax laetevirens* (Gay) Franchet (IV 10.5) and *Chusquea culeou* E. Desv. (IV 4.0). On the ground are hemicryptophytes like *Blechnum penna-marina* (Poir.) Kuhn (IV 9.3), *Blechnum magellanicum* (Desv.) Mett. (IV 7.8) and *Rubus geoides* Sm. (IV 3.9), among many other species. Exotic elements are not important but include some species like *Holcus lanatus* L.(IV 0.6), *Prunella vulgaris* L. (IV 0.6) and *Trifolium repens* L. (IV 0.5), among others. Diagnostic species with the greatest ISA values were *Nothofagus nitida* (ISA 1.0), *Hymenophyllum krauseanum* (ISV 0.7) and *Griselinia rusciflora* (Clos) Ball. (ISV 0.56).

No human disturbance affected these stands, although a few exotic species were detected. We recorded 67 species belonging to these stands, 7 of them exotic. These forests were distributed in the central and southern section of the Baker basin and in the northern section of the Pascua basin.

2) ***Pilgerodendron uviferum*** **forests** (*Empetro-Pilgerodendronetum uviferae*). Evergreen resinous multi-layered forests associated with flat and inundated areas (0 - 400 m) where extensive cover of the moss *Sphagnum magellanicum* Brid on the ground was observed. Dominant trees reached up to 6 m in height. *Pilgerodendron uviferum* dominated in cover and frequency (IV 30.5) at the upper layer, and *Empetrum rubrum* Vahl ex Willd. (IV 26.4) co-dominated at the ground layer. Other important species were *Gaultheria mucronata* (L.f.) Hook. et Arn. (IV 17.7), the epiphyte *Philesia magellanica* (IV 12.4) and the phanerophyte *Nothofagus antarctica* (IV 8.8). Diagnostic species with the greatest ISV values included *Pilgerodendron uviferum* (ISV 0.79), *Oreobolus obtusangulus* Gaudich. (ISV 0.57) and *Empetrum rubrum* (ISV 0.49). Large areas of these forests were burned during colonial times and remained standing, some of them providing seed trees. We recorded 36 species in these stands, all of them native. The stands were distributed in the southern segment of the Baker basin.

3) ***Nothofagus betuloides*** **forests** (*Nothofagetum betuloidis*). Evergreen forests associated with gentle slopes and mountainous areas from sea level to ~600 m elevation. Vegetation structure was multi-layered, dominated by *Nothofagus betuloides* (IV 30.9) in the upper tree layer, but co-dominated by other trees like *Desfontainia fulgens* (IV 10.7), *Podocarpus nubigena* (IV 10.4) and *Drimys winteri* (IV 9.5). The presence of many epiphytes was detected on the trees, including *Philesia magellanica* (IV 14.6) and ferns like *Serpyllopsis caespitosa* (Gaudich.) C.Chr. (IV 6.0), *Hymenophyllum tortuosum* Hook. et Grev. (IV 2.2) and *Hymenophyllum pectinatum* Cav. (IV 1.1). The shrub layer was also rich in species and included many microphanerophytes like *Gaultheria mucronata* (IV 17.2), *Berberis ilicifolia* L.f. (IV 8.0) and *Lebetanthus myrsinites* (Lam.) Dusen (IV 7.8), among others. Ground vegetation was also rich in species and includes *Blechnum penna-marina* (IV 5.7), *Sticherus quadripartitus* (Poir.) Ching (IV 5.2) and *Blechnum magellanicum* (IV 4.7). Diagnostic species with the greatest ISV values included *Nothofagus*

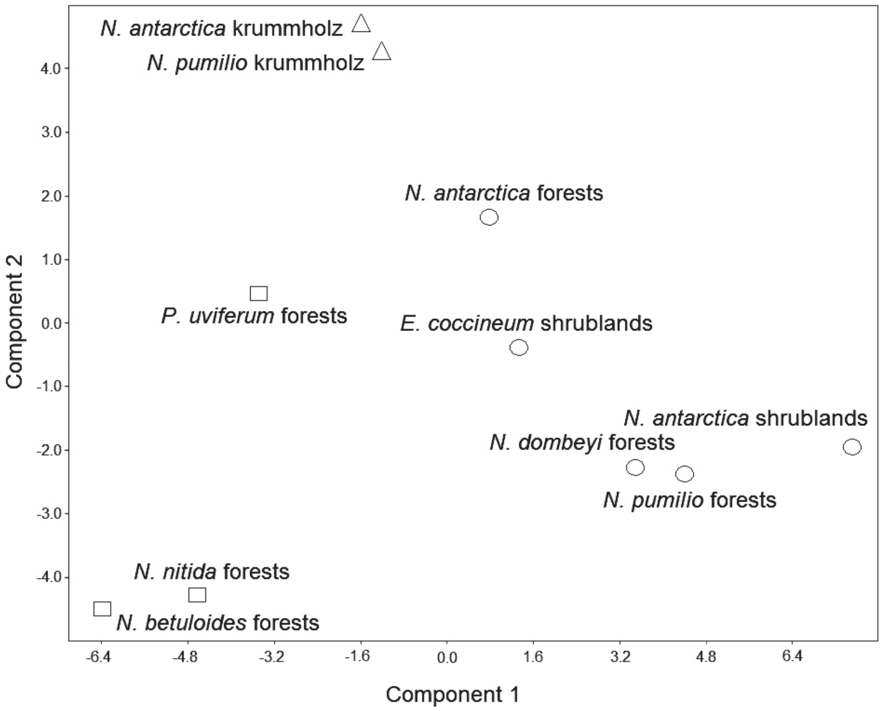

Figure 3. Diagram of principal component analysis (PCA) summarizing ordination of native woodland communities in the Baker and Pascua basins. The components explain 53.8% of the variance. Symbols: ○= meso-hygromorphic woodlands, mostly deciduous woodlands, □= hygromorphic woodlands, perennial woodlands, and Δ= high-Andean dwarf woodlands, krummholz communities.

Figura 3. Diagrama basado en el análisis de componentes principales (PCA) resumiendo la ordenación de las comunidades leñosas nativas en las cuencas del Baker y del Pascua. Los componentes explican el 53,8% de la varianza. Símbolos: ○= comunidades leñosas meso-higromórficas, principalmente conformadas por bosques caducifolios, □= comunidades leñosas higromórficas, conformadas por bosques perennes y Δ = matorrales achaparrados alto-andinos, comunidades del tipo krummholz.

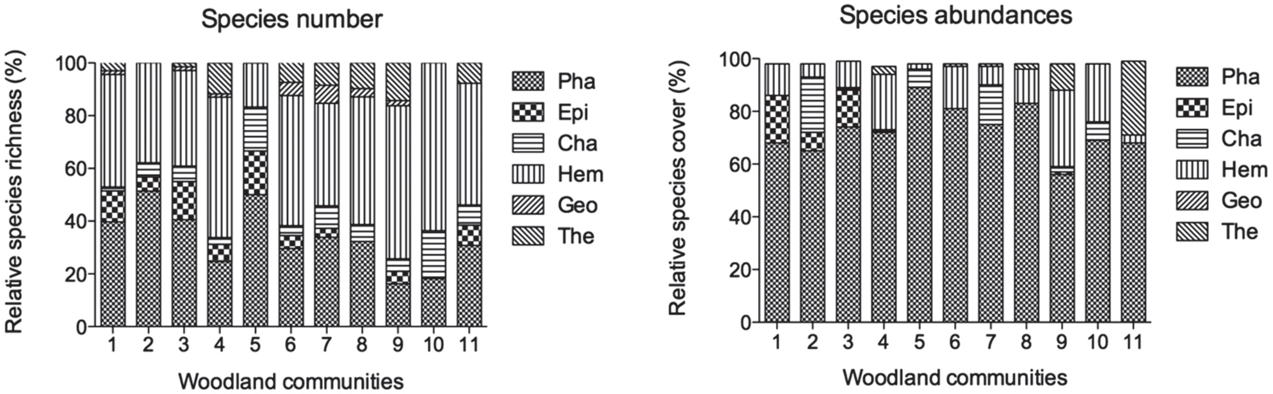

FIGURE 4. Raunkiaer life-form spectrum of different woodland communities in the Baker and Pascua basins according to species number (relative richness) and species abundances (relative cover) of species. Raunkiaer plant life-forms: Pha= Phanerophyte, Epi= Epiphytes, Cha= Chamaephyte, Hem= Hemicryptophyte, Geo= Geophyte, The= Therophyte. Name of communities: 1. *Nothofagus nitida* forests, 2. *Pilgerodendron uviferum* forests, 3. *Nothofagus betuloides* forests, 4. *Nothofagus pumilio* forests, 5. *Nothofagus pumilio* krummholz, 6. *Nothofagus dombeyi* forests, 7. *Embothrium coccineum* shrublands, 8. *Nothofagus antarctica* forests, 9. *Nothofagus antarctica* shrublands, 10. *Nothofagus antarctica* krummholz, 11. *Pinus contorta* plantations.

FIGURA 4. Espectros biológicos basados en las formas de vida de Raunkiaer para las diferentes comunidades leñosas en las cuencas de los ríos Baker y Pascua, de acuerdo al número de especies (riqueza relativa) y abundancia de especies (cobertura relativa). Formas de vida de Raunkiaer: Pha= fanerófitos, Epi= epífitos, Cha= caméfitos, Hem= hemicriptófitos, Geo= geófitos, The= terófitos. Nombre de las comunidades: 1. Bosques de *Nothofagus nitida*, 2. Bosques de *Pilgerodendron uviferum*, 3. Bosques de *Nothofagus betuloides*, 4. Bosques de *Nothofagus pumilio*, 5. Krummholz de *Nothofagus pumilio*, 6. Bosques de *Nothofagus dombeyi*, 7. Matorrales de *Embothrium coccineum*, 8. Bosques de *Nothofagus antarctica*, 9. Matorrales de *Nothofagus antarctica*, 10. Krummholz de *Nothofagus antarctica*, 11. Plantación de *Pinus contorta*.

betuloides (ISV 0.7), *Serpyllopsis caespitosa* (ISV 0.5) and *Desfontainia fulgens* (ISV 0.38), among others. No human disturbances were detected in these stands. We recorded a total of 68 species, all of them native. These stands were detected in the southern section of Baker and Pascua basins.

4) ***Nothofagus pumilio* forests** (*Mayteno-Nothofagetum pumilionis*). Deciduous forests associated with gentle slopes from ~100 m to ~1,000 m in elevation. Dominant trees reached up to 30 m in height and the vegetation structure was 3-layered, with *Nothofagus pumilio* (IV 52.2) dominating at the upper layer. *Gaultheria mucronata* (IV 17.7), *Maytenus disticha* (Hook.f.) Urban (IV 7.5), *Berberis microphylla* Hort ex. K.Koch (IV 6.3) and *Berberis darwinii* Hook. (IV 6.3) were the most important microphanerophytes in the shrub layer. The ground layer was rich in species, with many hemicryptophytes like *Blechnum penna-marina* (IV 7.8), *Fragaria chiloensis* (L.) Duch. (IV 7.2) and *Adenocaulon chilense* Poepp. ex Less. (IV 6.7) as natives, and *Trifolium repens* L. (IV 4.1) and *Taraxacum officinale* (L.) Weber (IV 3.2) as the most important exotics. Diagnostic species included *Nothofagus pumilio* (ISV 0.55), *Viola maculata* Cav. (ISV 0.49), *Maytenus disticha* (ISV 0.43), *Adenocaulon chilense* (ISV 0.25) and the orchid *Codonorchis lesonii* (Brongn.) Lindl. (ISV 0.18). The stands were affected by human disturbances like the use of wood for fuel and overgrazing by livestock. A consequent modification of the structure (e.g. reduction in canopy cover) and floristic composition of these forests (particularly the introduction of exotic species) was observed. We recorded a total of 79 species in these stands, 19 of them exotic. The distribution of these forests was restricted to the Baker basin.

5) ***Nothofagus pumilio* krummholz** (*Empetro-Nothofagetum pumiliae*). Deciduous and dense shrubland reaching up to 2 m in height, poor in species and associated with high elevation areas at the timberline from ~1,000 to 1,200 m. The vegetation structure was reduced to only 2 strata, with the upper layer dominated by *N. pumilio* (IV 116.6) and co-dominated by *Escallonia alpina* Poepp. & Endl. (IV 4.9). The floristic composition was poor, with *Empetrum rubrum* (IV 31.7) and *Gaultheria pumila* (L.f.) D.J.Middleton (IV 20.3) as chamaephytes and some hemicryptophytes like *Rubus geoides* (IV 21.6) and *Luzula racemosa* (IV 4.9). Diagnostic species included *Gaultheria pumila* (ISV 0.34) and *Rubus geoides* (ISV 0.29). Stands were pristine and not affected by human disturbances due to their difficult accessibility. We recorded a total of 6 species, all of them native. The distribution of these stands was restricted to the Baker basin.

6) ***Nothofagus dombeyi*** **forests** (*Chrysosplenio-Nothofagetum dombeyi*). Monospecific perennial forests located in low elevation areas near water bodies from sea level to ~500 m. Trees reached up to 40 m in height. The vegetation structure was 3-layered, with *N. dombeyi* (IV 64.8) as the dominant species and *Gaultheria mucronata* (IV 15.0), *Berberis microphylla* (IV 7.2), *Embothrium coccineum* J.R.Forst. et G.Forst (IV 6.6), and *Berberis darwinii* (IV 6.4) as important microphanerophytes in the shrub layer. The ground vegetation was rich in species, with *Blechnum penna-marina* (IV 12.6), *Adenocaulon chilense* (IV 6.5) and *Acaena ovalifolia* Ruiz & Pav. (IV 6.0) being the most important native hemicryptophytes. Some exotics included *Taraxacum officinale* (IV 3.2), *Holcus lanatus* (IV 2.0) and *Hypochaeris radicata* L. (IV 1.4), among others. Diagnostic species included *Nothofagus dombeyi* (ISV 0.89), *Ribes magellanicum* Poir. (ISV 0.18) and *Viola reichei* Skottsb. (ISV 0.16). Stands are affected by logging due to the use of wood as fuel by the rural landowners. Overgrazing of livestock was also observed in these stands, with evident browsing of shrubs and regenerating trees. We recorded a total of 81 species, 17 of them exotic. The distribution of these stands was restricted to the Baker basin.

7) ***Embothrium coccineum*** **shrublands** (*Embothrio-Pernettietum mucronatae*). Deciduous tree shrublands colonizing gentle slopes fluctuating from sea level to ~900 m. The vegetation structure was 3-layered, with *Embothrium coccineum* as the dominant phanerophyte but which did not form a continuous canopy (IV 33.3). *Gaultheria mucronata* was the dominant microphanerophyte at the shrub layer (IV 44.0). Other phanerophyte species were *Escallonia rosea* Griseb. (8.7), *Berberis microphylla* (IV 7.0) and *Nothofagus antarctica* (IV 5.3). The ground layer was rich in species, containing some chamaephytes like *Baccharis magellanica* (Lam.) Pers. (IV 14.4) and *Empetrum rubrum* (IV 12.0), and hemicryptophytes like *Festuca pyrogea* Speg. (IV 5.0), *Blechnum penna-marina* (IV 5.0) and *Fragaria chiloensis* (IV 4.4). Important exotics were *Hypochaeris radicata* (IV 2.5) and *Rumex acetosella* L. (IV 2.1). Diagnostic species included *Embothrium coccineum* (ISV 0.6), *Escallonia rosea* (ISV 0.51) and *Baccharis magellanica* (ISV 0.49) as phanerophytes. *Lycopodium paniculatum* Desv. (ISV 0.39) and *Gavilea odoratissima* Poepp. (ISV 0.34) were included as hemicryptophyte and geophyte diagnostic species, respectively. These shrublands were affected to a small degree by human disturbances derived from livestock production. We recorded a total of 59 species, 8 of them exotic. The distribution of these shrublands was restricted to the Baker basin, especially in the southern section.

8) ***Nothofagus antarctica*** **forests** (*Chusqueo-Nothofagetum antarcticae*). Deciduous forests associated with areas of depressions in the relief, close to river meanders from sea level to ~80 m. The structure was 3-layered, with *Nothofagus antarctica* (IV 47.0) as the dominant species, reaching up to 15 m in height. *Chusquea culeou* (IV 32.4) and *Embothrium coccineum* (IV 5.8) were the co-dominant species in the upper and shrub layer. Microphanerophytes in the shrub layer included *Escallonia virgata* (IV 13.8), *Gaultheria mucronata* (IV 9.2) and *Berberis microphylla* (IV 8.2). The ground vegetation was rich in species, containing many hemicryptophytes like *Blechnum penna-marina* (IV 16.6), *Acaena ovalifolia* (IV 7.3), and *Rubus geoides* (IV 4.2). Exotics included *Prunella vulgaris* (IV 4.4), *Taraxacum officinale* (IV 4.2) and *Trifolium repens* (IV 3.4). Diagnostic species were *Chusquea culeou* (ISA 0.76), *Escallonia virgata* (ISA 0.40) and *Blechnum penna-marina* (ISA 0.20), among others. In these forests we recorded a total of 31 species, 6 of them exotic. The distribution of these stands was restricted to the southern section of the Baker basin.

9) ***Nothofagus antarctica*** **shrublands** (*Anemone polyphyllae-Nothofagetum antarcticae*). Deciduous tree shrublands reaching up to 8 m in height, located in flat areas from sea level to ~500 m. The structure was 3-layered with *Nothofagus antarctica* dominating the upper layer (IV 47.2). Other phanerophytes such as *Berberis microphylla* (IV 6.2), *Discaria chacaye* (IV 4.8), and *Ribes cucculatum* (IV 3.5) were present but had values of little importance. The understory was rich in species, containing many natives like *Festuca pyrogea* (IV 8.7), *Blechnum penna-marina* (IV 8.0), *Anemone multifida* (IV 7.6) and *Fragaria chiloensis* (IV 6.6), and many exotics like *Taraxacum officinale* (IV 6.0), *Holcus lanatus* (IV 4.1), *Trifolium repens* (IV 3.6) and *Achillea millefolium* (IV 3.5), among others. The diagnostic species included *Anemone multifida* (ISV 0.40) and *Discaria chacaye* (ISV 0.29) as natives, and some exotics like *Achillea millefolium* (ISV 0.26), *Cerastium arvense* (0.16) and *Carduus nutans* (ISV 0.13), among others. Cattle heavily affected these shrublands because the ground plant cover was used as forage. *Pinus contorta* populations have also invaded some stands. In total we recorded 107 species in these stands, 38 of them exotic. The distribution of these forests occurred along the entire Baker basin.

10) ***Nothofagus antarctica*** **krummholz** (*Senecio acanthifoliae-Nothofagetum antarcticae*). Deciduous dwarf shrublands reaching up to a height of 1 m, poor in species and located in highlands from 600 to 900 m. The structure was 2-layered and dominated by *Nothofagus antarctica* (IV 85.9) in the upper layer as the only phanerophyte. The understory cover was dominated by *Gunnera magellanica* (IV 28.1) and *Senecio acanthifolius* (IV 23.3) as hemicryptophytes, and *Bolax caespitosa* (IV 17.5) and *Empetrum rubrum* (IV 10.4) as chamaephytes. The diagnostic species included *Senecio acanthifolius* (ISV 0.92), *Gunnera magellanica* (ISV 0.62) and *Bolax caespitosa* (ISV 0.60), among others. No human

disturbances were detected in these stands. In total we recorded 11 species, all of them native. These stands were distributed along the entire Pascua basin.

11) ***Pinus contorta*** **plantations**. Exotic monoculture located near the village of Cochrane, between 200 - 300 m. The structure was 3-layered with *Pinus contorta* (IV 67.2) having the major importance value. *Nothofagus antarctica* (IV 26.3) was also an important phanerophyte. Microphanerophytes in the shrub layer included *Berberis microphylla* (IV 7.3) and *Gaultheria mucronata* (IV 2.4). The ground vegetation was poor in species and included some natives like *Nertera granadensis* (IV 13.5), *Acaena ovalifolia* (IV 7.3) and *Osmorhiza chilensis* (IV 4.7), and some exotics like *Agrostis stolonifera* (IV 44,3), *Taraxacum officinale* (IV 12.2) and *Trifolium repens* (IV 2.4). Diagnostic species were *Pinus contorta* (ISV 1.0), *Agrostis stolonifera* (ISV 0.87) and *Nertera granadensis* (ISV 0.51). Some *Pinus contorta* individuals were growing outside of plantations and invading native communities. In total we recorded 13 species, 4 of them exotic. The distribution of these stands is restricted to close to the village of Cochrane in the Baker basin.

Community comparisons and disturbance patterns

Mean cover and richness of native and exotic plant species as well as diversity indices (Shannon and Beger-Parker) are presented in Table I. Forest communities dominated by *Nothofagus nitida*, *Pilgerodendron uviferum* and *Nothofagus betuloides* have the highest richness as well as cover and Shannon diversity values, indicating relatively equitable participation in cover for many species. In these communities, exotic elements are virtually absent, with only *Nothofagus nitida* forests having low values of exotics. On the other hand, communities containing the lowest values of richness are *Nothofagus pumilio* krummholz, *Nothofagus antarctica* krummholz and the *Pinus contorta* plantations. These communities also contain the lowest Shannon index values but have the highest Berger-Parker index values, indicating the higher cover of the dominant woods. The communities most invaded by exotics are *Nothofagus antarctica* shrublands, *Nothofagus pumilio* forests and *Pinus contorta* plantations, while 4 communities have no exotics (*Pilgerodendron uviferum* forests, *Nothofagus betuloides* forests, *Nothofagus antarctica* krummholz and *Nothofagus pumilio* krummholz).

Similarities among communities based on the Jaccard coefficient vary from 0.49 between *Nothofagus dombeyi* forests and *Embothrium coccineum* shrublands (the highest value) to no similarity (value 0 for the index) between *Nothofagus pumilio* krummholz and *Pinus contorta* plantations, revealing that each community has its own identity in terms of species composition (Table II).

Table I. Diversity structure of woody communities in the Baker and Pascua basins.

Tabla I. Diversidad estructural de las comunidades leñosas en las cuencas de los ríos Baker y Pascua.

Woodland community	Native richness	Exotic richness	Native covers	Exotic covers	Shannon Index	Berger Parker Index
Nothofagus nitida forests	14.8 ± 3.4	0.4 ± 0.8	140.5 ± 31.5	1.0 ± 4.2	1.878 ± 0.311	0.366 ± 0.122
Pilgerodendron uviferum forests	20.4 ± 3.2	-	173.1 ± 20.6	-	2.175 ± 0.148	0.305 ± 0.058
Nothofagus betuloides forests	16.2 ± 3.9	-	149.7 ± 44.5	-	1.995 ± 0.340	0.313 ± 0.121
Nothofagus pumilio forests	13.8 ± 3.1	2.2 ± 2.0	123.7 ± 34.4	7.3 ± 11.4	1.636 ± 0.348	0.485 ± 0.125
Nothofagus pumilio krummholz	3.5 ± 1.4	-	110.0 ± 14.5	-	0.371 ± 0.329	0.891 ± 0.104
Nothofagus dombeyi forests	11.6 ± 3.5	1.6 ± 2.5	127.0 ± 34.0	4.0 ± 8.0	1.276 ± 0.379	0.601 ± 0.168
Embothrium coccineum shrublands	12.3 ± 2.5	0.8 ± 0.9	132.5 ± 49.1	0.8 ± 0.9	1.609 ± 0.189	0.429 ± 0.110
Nothofagus antarctica forests	8.9 ± 2.4	1.3 ± 1.6	138.6 ± 37.3	7.4 ± 11.4	1.512 ± 0.197	0.411 ± 0.079
Nothofagus antarctica shrublands	12.2 ± 2.8	4.5 ± 2.5	113.4 ± 42.6	14.5 ± 19.7	1.716 ± 0.311	0.440 ± 0.130
Nothofagus antarctica krummholz	6.0 ± 2.1	-	136.6 ± 33.7	-	0.795 ± 0.371	0.728 ± 0.185
Pinus contorta plantations	3.3 ± 1.6	2.9 ± 0.7	26.6 ± 22.6	103.9 ± 41.9	0.879 ± 0.429	0.610 ± 0.239

Table II. Jaccard index values for all pairs of woodland communities.

Tabla II. Valores para el índice de Jaccard para todos los pares de comunidades comparados.

Community type	1	2	3	4	5	6	7	8	9	10	11
1. *Nothofagus nitida* forests	1.00	0.24	0.38	0.26	0.03	0.34	0.29	0.32	0.21	0.04	0.13
2. *Pilgerodendron uviferum* forests		1.00	0.37	0.15	0.05	0.14	0.22	0.18	0.10	0.07	0.07
3. *Nothofagus betuloides* forests			1.00	0.24	0.06	0.18	0.23	0.15	0.15	0.08	0.05
4. *Nothofagus pumilio* forests				1.00	0.06	0.45	0.35	0.29	0.43	0.05	0.14
5. *Nothofagus pumilio* krummholz					1.00	0.04	0.02	0.03	0.05	0.13	0.00
6. *Nothofagus dombeyi* forests						1.00	0.49	0.29	0.39	0.02	0.11
7. *Embothrium coccineum* shrublands							1.00	0.29	0.29	0.04	0.09
8. *Nothofagus antarctica* forests								1.00	0.25	0.05	0.26
9. *Nothofagus antarctica* shrublands									1.00	0.04	0.10
10. *Nothofagus antarctica* krummholz										1.00	0.04
11. *Pinus contorta* plantations											1.00

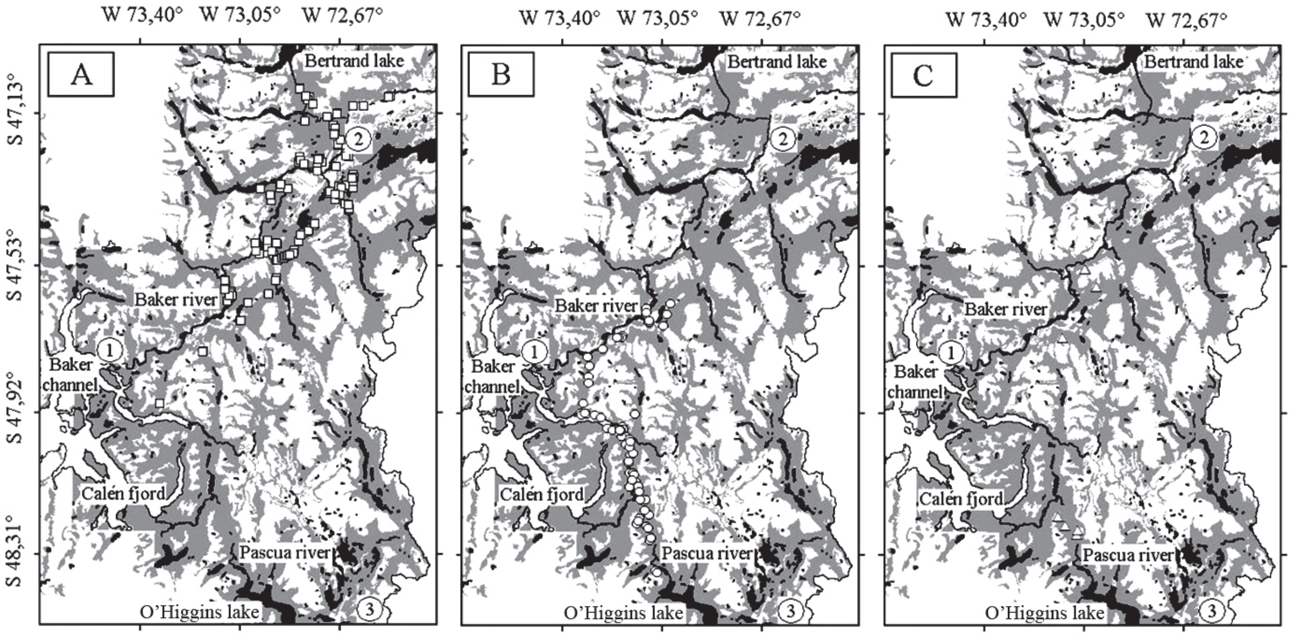

Figure 5. Map showing the location of phytosociological relevés in the study area: A) relevés belonging to the meso-hygromorphic woodlands, B) relevés belonging to the hygromorphic woodlands and C) relevés belonging to the high-Andean dwarf woodlands. The numbers indicates the towns close to the basins: 1) Caleta Tortel, 2) Cochrane and 3) the village of O'Higgins.

Figura 5. Mapa mostrando la locación de los relevamientos fitosociológicos en el área de estudio: A) relevamientos pertenecientes e las comunidades leñosas meso-higromórficas, B) relevamientos correspondientes a las comunidades leñosas higromórficas y C) relevamientos correspondientes a los matorrales achaparrados alto-andinos. Los números indican los poblados cercanos a las cuencas: 1) Caleta Tortel, 2) Cochrane y 3) Villa O'Higgins.

A weak correlation between the number of exotics and the distance to roads was observed (*r*= -0.213, *p*= 0.001) when all relevés (n= 256) were evaluated, indicating that roads have little influence as corridors for exotics. Moreover, these correlations are stronger for some communities when they are analyzed independently, indicating specific responses of communities. Thus, the presence of exotics in *Nothofagus pumilio* forests is strongly correlated with the elevation of the relevés (*r*= -0.494, *p*= 0.002) as well as with the distance to roads (*r*= -0.493, *p*= 0.002). Similarly, *Nothofagus antarctica* shrublands also showed significant correlations between elevation of relevés and number of exotics (*r*= -0.454, *p*= 0.001), but exotic presence in this community is not significantly influenced by distance to roads.

DISCUSSION

Composition and distribution of woodland communities

The native vegetation in the study area can be classified into 3 groups (Fig. 4): 1) Meso-hygromorphic woodlands, mostly composed of deciduous woodlands with continental influence, 2) Hygromorphic woodlands, consisting of evergreen woodlands with oceanic influence, and 3) High-Andean dwarf woodlands, consisting of krummholz communities.

1) **Meso-hygromorphic woodlands** (Figure 5A), consisting mainly of deciduous woodlands in warmer and drier places in the NE section of the study area with sub-hyperoceanic influence (Luebert & Pliscoff 2006), typically within the Baker basin. The communities included here are *N. antarctica* forests, *E. coccineum* tree shrublands, *N. dombeyi* forests, *N. pumilio* forests and *N. antarctica* tree shrublands. The vegetation in the Baker basin is more heterogeneous, consisting mainly of a mosaic of vegetation formations with greater or lesser degrees of disturbance due to livestock activities, but its structure is less complex and contains a smaller number of species as well as lower diversity. *N. dombeyi* forests were described in the study area by Hambleton (1936), who located these stands in the northern portion of the Baker basin. Other communities from this belt, like *N. pumilio* forests and *N. antarctica* forests, were also mentioned for this basin from a phytogeographical point of view (Reiche 1934), but a numerical comparison is hard to establish here. In this meso-hygromorphic woodland group, *N. dombeyi* forests are the only perennial community, which, as a typical component of the northern-Valdivian phytogeographical region (Ramírez *et al.* 1997, Amigo & Ramírez 1998), reaches its southern distribution range in the study area. The southern limit of this vegetation as a whole is the so-called 'Cold Temperate Zone' (Godley 1960, Holdgate 1960, Skottsberg 1960), and was established at 48°S by Godley (1960). Our southernmost record for this belt reached 47.9°S.

2) **Hygromorphic woodlands** (Fig. 5B), consisting of perennial woodlands in colder and more humid places in the SW section of the study area, with euhyperoceanic influence (Luebert & Pliscoff 2006), present at the southern section of the Baker river basin and along the Pascua basin. The communities included here are forests dominated by *N. nitida*, forests dominated by *Pilgerodendron uviferum* and forests dominated by *N. betuloides*. The vegetation is more homogeneous than the meso-hygromorphic woodlands, but its structure is complex, containing higher richness and diversity than the drier belt (Amigo *et al.* 2004). Forests dominated by *N. betuloides* were described by Hambleton (1936), who extended their distribution to the archipelagic areas, probably confusing the species with *N. nitida*. The community dominated by *N. nitida*, however, was correctly mentioned by Reiche (1934). It is situated in areas near the mouth of the Baker River. *N. nitida* stands reach their southern distribution limit at 49°S along the coastline, while *N. betuloides* and *P. uviferum* stands reach the antiboreal macrobioclimatic belt beyond 52°S (Oberdorfer 1960, Amigo & Ramírez 1998, Luebert & Pliscoff 2006). Pisano (1972), however, pointed out that it is not really possible to speak of *Pilgerodendron uviferum* forests because of the small size of the stands.

3) **High-Andean dwarf woodlands** (Fig. 5C), consisting of deciduous krummholz communities at the snowline, forming a continuous belt at upper elevations. Krummholz dominated by *N. pumilio* are distributed in the Baker River basin, while krummholz dominated by *N. antarctica* are located in the Pascua River basin. Hambleton (1936) mentioned the presence of krummholz communities in the Baker basin above 1,000 m altitude, while Pisano (1972), based on Davison's data from New Zealand's second expedition to the North Patagonian Ice Field, described *N. antarctica* krummholz communities with *Empetrum rubrum*. This last species, however, has minor importance with regard to frequency and cover in our plots.

Disturbance patterns affecting woodland communities

Four major types of current human disturbances affecting the woodland communities have been observed: 1) logging for fuel wood and construction timber, 2) overgrazing of ground vegetation by livestock, 3) road widening in forested lands and 4) invasion of some stands by *Pinus contorta*. All of these disturbances are confined to the Baker basin where roads, exotic plantations and human population are present. The vegetation in the Pascua basin, however, remains completely pristine. The disturbances occurring in the Baker basin are slowly changing the structure and composition of the woodland communities by means of an increase in the introduction of exotic plant species, reduction in cover of native dominant ones, mortality of tree seedlings and erosion, among other effects, as occurs in other similarly impacted forest ecosystems (Ramírez *et al.* 1981, Raffaele *et al.* 2007, Quintanilla 2008, Speziale *et al.* 2010, Vidal & Reif 2011). The fact that exotic species occur in the Baker basin supports the idea that a process of biotic homogeneization of their vegetation communities (*sensu* Olden & Rooney 2006) may occur, leading to an increase in similarity among regional floras. Although this study shows that roads contribute little as corridors for exotic species, the sample design cannot distinguish among the synergic effects of the disturbances mentioned above.

The fact that these disturbances are confined to the Baker River basin is related to the history of the place. A dramatic transformation of forest into open vegetation areas was carried out between 1930-1950 in the northern part of the Aysén Region, when Chilean-European settlers burned great extensions of woodlands for livestock production (CONAF 2006). More humid and inaccessible forests in southern areas and archipelagic regions, however, remained undisturbed (Quintanilla 2008). Thus, human establishment and road construction were possible only in northern areas where it was possible to carry out livestock activities. Until now, only a few studies have aimed to evaluate the resiliency of these forests after fire disturbance (e.g. Quintanilla 2008), and it seems that few burned forest stands were able to recover after fire. This led to a structural change in the landscape, where anthropogenic prairies, post-fire shrublands and park-like stands developed a heterogeneous landscape matrix. Moreover, the current influence of livestock in forests through extensive grazing practices are leading to changes in the understory composition such as an increment in biodiversity due to exotic plant species (Sánchez-Jardón *et al.* 2010), especially in open canopy stands. However, it is interesting to note the low levels of biological invasions reported for our study in unburned forest stands and the relatively higher species richness and diversity recorded for forests in the Pascua basin.

Although our objective here is not directly to evaluate the effects of past or current disturbances, it seems appropriate to highlight the apparently low level of disturbances affecting these forests, as we show through the biodiversity indicators evaluated. This situation appears to offer even an interesting opportunity for researchers to evaluate undisturbed biogeographical and ecological patterns and processes occurring at one of the most remote, isolated and unpolluted landscapes in southern Chile.

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Annex 1. Diagnostic species for each woodland community based on the indicator species values and *p* values (∗ ≤ 0.05; ∗∗ ≤ 0.005: ∗∗∗ ≤ 0.001).

Anexo 1. Especies diagnósticas para cada comunidad leñosa basado en los valores indicadores y sus correspondientes valores de probabilidad *p* (∗ ≤ 0,05; ∗∗ ≤ 0,005: ∗∗∗ ≤ 0,001).

Community type / Species	Family	Origin	Life Form	ISA Value
Nothofagus nitida forests				
Azara lanceolada Hook.f.	Flacourtiaceae	Native	Phanerophyte	0.39 ***
Blechnum magellanicum (Desv.) Mett.	Blechnaceae	Native	Hemicryptophyte	0.29 **
Campsidium valdivianum (Phil.) Skottsb.	Bignoniaceae	Native	Epiphyte	0.41 ***
Drimys winteri J.R.Forst. et G. Forst.	Winteraceae	Native	Phanerophyte	0.38 ***
Griselina ruscifolia (Clos) Ball.	Griseliniaceae	Native	Epiphyte	0.56 ***
Hymenophyllum krauseanum Phil.	Hymenophyllaceae	Native	Ephiphyte	0.70 ***
Lomatia ferruginea (Cav.) R. Br.	Proteaceae	Native	Phanerophyte	0.23 ***
Mitraria coccinea Cav.	Gesneriaceae	Native	Epiphyte	0.47 ***
Nothofagus nitida (Phil.) Krasser	Nothofagaceae	Native	Phanerophyte	1.00 ***
Podocarpus nubigena Lindl.	Podocarpaceae	Native	Phanerophyte	0.50 ***
Pseudopanax laetevirens (Gay) Franchet	Araliaceae	Native	Phanerophyte	0.46 ***
Weinmannia trichosperma Cav.	Cunoniaceae	Native	Phanerophyte	0.22 ***

Community type / Species	Family	Origin	Life Form	ISA Value
Pilgerodendron uviferum forests				
Berberis ilicifolia L.f.	Berberidaceae	Native	Phanerophyte	0.40 ***
Carex magellanica Lam.	Cyperaceae	Native	Hemicryptophyte	0.49 ***
Empetrum rubrum Vahl ex Willd.	Empetraceae	Native	Chamaephyte	0.49 ***
Gaimardia australis Gaudich.	Centrolepidaceae	Native	Chamaephyte	0.29 **
Hypochaeris palustris (Phil.) De Wild.	Asteraceae	Native	Hemicryptophyte	0.29 **
Juncus microcephalus Kunth	Juncaceae	Native	Hemicryptophyte	0.29 **
Lebetanthus myrsinites (Lam.) Dusen	Epacridaceae	Native	Phanerophyte	0.48 ***
Macrachaenium gracile Hook.f.	Asteraceae	Native	Hemicryptophyte	0.40 **
Myrteola nummularia (Poir.) O.Berg	Myrtaceae	Native	Chamaephyte	0.31 **
Oreobolus obtusangulus Gaudich.	Cyperaceae	Native	Hemicryptophyte	0.57 ***
Philesia magellanica J.F.Gmel.	Philesiaceae	Native	Epiphyte	0.44 *
Pilgerodendron uviferum (D.Don) Florin	Cupressaceae	Native	Phanerophyte	0.79 **
Nothofagus betuloides forests				
Desfontainia fulgens D.Don	Desfontainiaceae	Native	Phanerophyte	0.38 ***
Escallonia rubra (Ruiz et Pav.) Pers.	Escalloniaceae	Native	Phanerophyte	0.24 ***
Hymenophyllum tortuosum Hook.et Grev.	Hymenophyllaceae	Native	Epiphyte	0.22 *
Luzuriaga marginata (Banks et Sol. ex Gaertn.) Benth.	Luzuriagaceae	Native	Epiphyte	0.30 **
Nothofagus betuloides (Mirbel) Oersted	Nothofagaceae	Native	Phanerophyte	0.70 ***
Schoenus andinus (Phil.) H.Pfeiffer	Cyperaceae	Native	Hemicryptophyte	0.20 *
Serpyllopsis caespitosa (Gaudich.) C.Chr.	Hymenophyllaceae	Native	Epiphyte	0.50 ***
Sticherus quadripartitus (Poir.) Ching	Gleicheniaceae	Native	Hemicryptophyte	0.22 **
Nothofagus pumilio forests				
Adenocaulon chilense Poepp. ex Less.	Asteraceae	Native	Hemicryptophyte	0.25 **
Codonorchis lessonii (Brongn.) Lindl.	Orchidaceae	Native	Geophyte	0.18 *
Lycopodium magellanicum (P.Beauv.) Sw.	Lycopodiaceae	Native	Hemicryptophyte	0.16 *
Maytenus disticha (Hook.f.) Urban	Celastraceae	Native	Phanerophyte	0.43 ***
Nothofagus pumilio (Poepp. et Endl.) Krasser	Nothofagaceae	Native	Phanerophyte	0.55 ***
Osmorhiza chilensis Hook et Arn.	Apiaceae	Native	Hemicryptophyte	0.23 **
Poa pratensis L.	Poaceae	Exotic	Hemicryptophyte	0.20 **
Viola maculata Cav.	Violaceae	Native	Hemicryptophyte	0.49 ***
Nothofagus pumilio krummholz				
Gaultheria pumila (L.f.) D.J.Middleton	Ericaceae	Native	Chamaephyte	0.34 ***
Rubus geoides Sm.	Rosaceae	Native	Hemicryptophyte	0.29 **
Nothofagus dombeyi forests				
Nothofagus dombeyi (Mirb.) Oerst.	Nothofagaceae	Native	Phanerophyte	0.89 ***
Ribes magellanicum Poir.	Grossulariaceae	Native	Phanerophyte	0.18 *
Viola reichei Skottsb.	Violaceae	Native	Hemicryptophyte	0.16 *
Embothrium coccineum shrublands				
Baccharis magellanica (Lam.) Pers.	Asteraceae	Native	Chamaephyte	0.49 ***
Embothrium coccineum J.R.Forst. et G.Forst.	Proteaceae	Native	Phanerophyte	0.60 ***
Escallonia rosea Griseb.	Escalloniaceae	Native	Phanerophyte	0.51 ***
Gaultheria mucronata (L.f.) Hook. et Arn.	Ericaceae	Native	Phanerophyte	0.28 ***
Gavilea odoratissima Poepp.	Orchidaceae	Native	Geophyte	0.34 ***
Lycopodium paniculatum Desv.	Lycopodiaceae	Native	Hemicryptophyte	0.39 ***
Nothofagus antarctica forests				
Blechnum penna-marina (Poir.) Kuhn	Blechnaceae	Native	Hemicryptophyte	0.20 **
Chusquea culeou E. Desv.	Poaceae	Native	Phanerophyte	0.76 ***
Escallonia virgata (Ruiz et Pav.) Pers.	Escalloniaceae	Native	Phanerophyte	0.40 ***

Community type / Species	Family	Origin	Life Form	ISA Value
Ranunculus trullifolius Hook.f.	Ranunculaceae	Native	Hemicryptophyte	0.18 ***
Scirpus inundatus (R.Br.) Poir.	Cyperaceae	Native	Hemicryptophyte	0.15 *
Nothofagus antarctica shrublands				
Achillea millefolium L.	Asteraceae	Exotic	Hemicryptophyte	0.26 *
Anemone multifida Poir.	Ranunculaceae	Native	Hemicryptophyte	0.40 ***
Carduus nutans L.	Asteraceae	Exotic	Therophyte	0.13 *
Cerastium arvense L.	Caryophyllaceae	Exotic	Hemicryptophyte	0.16 *
Discaria chacaye (G.Don) Tortosa	Rhamnaceae	Native	Phanerophyte	0.29 **
Festuca pyrogea Speg.	Poaceae	Native	Hemicryptophyte	0.27 *
Fragaria chiloensis (L.) Duch.	Rosaceae	Native	Hemicryptophyte	0.23 **
Geum magellanicum Pers.	Rosaceae	Native	Hemicryptophyte	0.18 *
Jarava psylantha (Speg.) Penail.	Poaceae	Native	Hemicriptophyte	0.16 *
Misodendrum punctulatum Banks ex DC.	Misodendraceae	Native	Epiphyte	0.24 **
Phacelia secunda J.F.Gmel.	Hydrophyllaceae	Native	Hemicryptophyte	0.17 *
Ribes cucullatum Hook. et Arn.	Grossulariaceae	Native	Phanerophyte	0.18 **
Rumex acetosella L.	Polygonaceae	Exotic	Hemicryptophyte	0.25 **
Nothofagus antarctica krummholz				
Acaena pumila Vahl	Rosaceae	Native	Hemicryptophyte	0.38 **
Bolax caespitosa Hombr. et Jacquinot	Apiaceae	Native	Chamaephyte	0.60 **
Caltha dionaeifolia Hook.f.	Ranunculaceae	Native	Hemicryptophyte	0.40 ***
Gunnera magellanica Lam.	Gunneraceae	Native	Hemicryptophyte	0.62 ***
Marsippospermum grandiflorum (L.f.) Hook.	Juncaceae	Native	Hemicryptophyte	0.30 **
Nothofagus antarctica (G.Forst.) Oerst.	Nothofagaceae	Native	Phanerophyte	0.31 ***
Perezia linearis Less.	Asteraceae	Native	Hemicryptophyte	0.18 *
Senecio acanthifolius Hombr. et Jacquinot	Asteraceae	Native	Hemicryptophyte	0.92 ***
Senecio darwinii Hook et Arn.	Asteraceae	Native	Chamaephyte	0.40 **
Pinus contorta plantations				
Agrostis stolonifera L.	Poaceae	Exotic	Hemicryptophyte	0.87 ***
Nertera granadensis (Mutis ex L.f.) Druce	Rubiaceae	Native	Hemicryptophyte	0.51 ***
Pinus contorta Douglas ex Loudon	Pinaceae	Exotic	Phanerophyte	1.00 ***

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