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Original Article

Patterns of composition, richness and phylogenetic diversity of woody plant communities of *Quillaja saponaria* Molina (Quillajaceae) in the Chilean sclerophyllous forest

Patrones de composición, riqueza y diversidad filogenética de las comunidades de plantas leñosas de *Quillaja saponaria* Molina (Quillajaceae) en el bosque esclerófilo de Chile

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ABSTRACT

Sclerophyllous forest is among the most representative types of woody plant communities in central Chile where *Quillaja saponaria* is considered to be one of the most important species. In this study, we analysed the main factors that explain the geographical patterns of variation in composition, richness and phylogenetic diversity of woody plant communities in the Chilean sclerophyllous forest where *Quillaja saponaria* is present. Vegetation surveys were performed for trees and shrubs in thirty-nine sites from 30° to 38° of latitude South in the Mediterranean biome of Chile. Composition, richness, alfa diversity and phylogenetic diversity metrics of the communities were calculated and associated with spatial (latitude, longitude and altitude), climate (annual mean temperature, annual precipitation, aridity), and disturbance variables (type of adjacent vegetation matrix) using multiple regression models. Sixty taxa were identified, distributed in 29 families, including 23 trees and 37 shrubs. A significant effect of the type of adjacent vegetation matrix (i.e. agricultural land, commercial forestry plantation or natural forest) on diversity and composition of the sampled communities was found. Significant effects of latitude on diversity, and altitude, latitude and annual mean temperature on composition were also found. Metrics of phylogenetic diversity and structure were only associated with altitude and latitude. In conclusion, diversity, composition and phylogenetic structure patterns of sclerophyllous forest communities are associated with spatial and climate variables, and anthropogenic disturbance has also caused important changes in these communities.

Keywords: Diversity, forest fragmentation, Mediterranean flora, phylogenetic diversity, vegetation matrix.

RESUMEN

El Bosque Esclerófilo es uno de los tipos más representativos de las comunidades de plantas leñosas en el centro de Chile, donde *Quillaja saponaria* es considerada una de las especies más importantes. En este trabajo se analizaron los principales factores que explican la distribución geográfica de la variación en la composición, riqueza y diversidad filogenética de las comunidades de plantas leñosas del Bosque Esclerófilo de Chile, donde *Q. saponaria* está presente. Se llevaron a cabo censos de vegetación de árboles y arbustos en treinta y nueve sitios desde los 30° a los 38° de latitud sur en el bioma mediterráneo de Chile. Se calcularon la composición, riqueza, diversidad alfa y la diversidad filogenética de las comunidades y se asociaron con variables espaciales (latitud, longitud y altitud), climáticas (temperatura media anual, precipitación anual, aridez), y variables de perturbación (tipo de matriz de la vegetación adyacente) usando modelos de regresión múltiple. Se identificaron sesenta taxones, distribuidos en 29 familias, incluyendo 23 árboles y 37 arbustos. Se encontró un efecto significativo del tipo de matriz de vegetación adyacente (es decir, tierras agrícolas, plantaciones forestales comerciales o bosques naturales) en la diversidad y composición de las comunidades estudiadas. También se encontraron efectos significativos de la latitud sobre la diversidad; y de la altitud, latitud y temperatura media anual sobre la composición de las comunidades, la diversidad filogenética sólo se asoció con la altitud y la latitud. En conclusión, la diversidad, composición y patrones de estructura filogenética se asocian con variables espaciales y climáticas; y las perturbaciones antropogénicas también han provocado cambios importantes en estas comunidades.

Palabras clave: Diversidad, fragmentación del bosque, flora mediterránea, diversidad filogenética, matriz vegetacional.

INTRODUCTION

Mediterranean biomes occur between approximately 30° to 40° of North and South latitude on the west sides of continents (Archibold 1995) and are known for their outstanding biodiversity and high level of endemism (Lavorel *et al*. 1998, Tang 2006). Worldwide, the total area covered by Mediterranean vegetation is 1,996,300 km^2 (Keeley *et al*. 2012), divided into five floristic biome subtypes: 1) Mediterranean basin (Europe), 2) Californian (USA), 3) Chilean (Chile), 4) Capensic (South Africa) and 5) Australian (Australia) (Archibold 1995). The Chilean subtype ranks third in area, with 111,725 km^2, being surpassed by the Mediterranean and Australian regions (Keeley *et al*. 2012). These five areas account for less than 5% of the surface of the Earth, but the richness of vascular plant species in these communities represents about 20% of known species (Cowling *et al.* 1996).

Due to their high biological diversity, Mediterranean ecosystems have been recognized as biodiversity hotspots and a prime target for conservation efforts (Matesanz & Valladares 2014, Squeo *et al.* 2012). These communities are not only exposed to a changing climate (Matesanz & Valladares 2014), but also have been profoundly transformed by human activities for centuries or millenia in the case of the European region. However, many of the traditional management practices of Mediterranean environments are also changing in the present time, resulting in increased disturbance (Arroyo *et al.* 1999, Briones *et al.* 2013, Mittermeier *et al.* 1998, Myers *et al.* 2000).

It is widely acknowledged that besides habitat loss *per se*, fragmentation is also a major threat for natural communities. Fragmentation has an effect on the composition and structure of the forest, and contributes to the degradation and loss of biodiversity (Harper *et al.* 2005). The edge effect, caused by fragmentation, creates gradients in abiotic variables such as sunlight, wind and moisture from the edge to the interior of the fragments, and also facilitates the establishment of invasive species, with important consequences for the richness, composition and structure of the remaining natural communities (Harper *et al.* 2005).

Recently, the incorporation of phylogenetic information into the analysis of community structure and composition has provided a new understanding of the processes that underlie species assemblages and their dynamics (Buerki *et al.* 2015, Cavender-Bares *et al.* 2009). Increasing evidence shows the importance of incorporating the evolutionary history of the species in the analysis of conservation strategies, particularly given that the likelihood of extinction is not random, and that the phylogenetic diversity is lost at higher rates than species diversity (Buerki *et al*. 2015). Importantly, different patterns of phylogenetic diversity are expected depending on whether environmental filtering or biotic interactions (*i.e.* competition) predominate as processes shaping a particular community (Cavender-Bares *et al*. 2009). Several studies have now used this approach to evaluate how the phylogenetic structure of different plant and animal communities vary along altitudinal and latitudinal gradients (Hoiss *et al.* 2012, Machac *et al.* 2011, Qian *et al.* 2013) and also the effect of forest fragmentation on the phylogenetic diversity in tree communities (*e.g.* Arroyo-Rodríguez *et al*. 2012).

In the Mediterranean biome of Chile, the sclerophyllous forest is one of the most representative types of woody plant communities in the biodiversity hotspot called the Chilean Winter Rainfall-Valdivian Forest (Arroyo *et al.* 1999, Briones *et al.* 2013, Mittermeier *et al.* 1998, Myers *et al.* 2000). In these woody communities, *Quillaja saponaria* is considered one of the most important, abundant and representative species and therefore can be considered as a foundation species; *i.e.* a species that has a strong role in structuring the community (Gajardo 1994). The species also has a high economic importance since it is not only a source of timber (García & Ormazabal 2008), but it is also melliferous (Díaz-Forestier *et al.* 2009, Montenegro *et al.* 2009a, Montenegro *et al.* 2008, Montenegro *et al.* 2003, Montenegro *et al.* 2009b). Furthermore, the bark yields saponins (San Martín & Briones 1999), and medicinal coadjuvants (Kensil *et al*. 1991, San Martín & Briones 1999). Other abundant species in these forests are *Acacia caven, Prosopis chilensis, Cryptocarya alba, Lithrea caustica, Maytenus boaria, Peumus boldus, Schinus areira, Kageneckia oblonga, Beilschmiedia berteroana, B. miersii* and *Crinodendron patagua* (Hechenleitner *et al*. 2005).

Unfortunately, the Chilean Winter Rainfall-Valdivian Forest hotspot has experienced a strong decline of natural forest areas. In particular, sclerophyllous forest communities have been under strong pressure from changes in land use, either to forestry plantations, agriculture, and urbanization (Arroyo *et al*. 1999, Hechenleitner *et al*. 2005, Squeo *et al*.

2010) and the remaining forest is estimated to cover less than 40% of its original area (Hechenleitner *et al*. 2005). For this reason, this area is considered a priority for conservation (Arroyo *et al.* 1999, Briones *et al.* 2013, Mittermeier *et al.* 1998, Myers *et al.* 2000). In addition, the effects of climate change are expected to produce a further decrease in cover area of the sclerophyllous forest in central Chile, together with a southwards displacement of about 350 km by year 2100 (Bambach *et al*. 2013).

The aim of the present work was to characterise and explain the geographical patterns of composition, richness, phylogenetic diversity, and similarity of woody plant communities of the Chilean sclerophyllous forest, based on sites with presence of *Quillaja saponaria*, in terms of spatial, climate and disturbance variables. In particular, we hypothesized that habitat fragmentation, and particularly the type of the adjacent plant matrix surrounding the sampled sites, would have an effect on the diversity and composition of the communities, with an agricultural matrix being associated with lower diversity than that found in communities where the matrix is native forest.

MATERIALS AND METHODS

Species and study area

Sclerophyllous forest communities in Chile occur from the Coquimbo Region in the north to the O'Higgins Region in the south (Hechenleitner *et al.* 2005), although Gajardo (1994) and Moreira-Muñoz (2011) extended the range further south into the central valley of the Maule and Bío-Bío Regions. According to the second classification, the distribution of sclerophyllous communities coincides entirely with the range of *Q. saponaria*. The climate type in which these communities develop is Mediterranean with a dry summer season, changing to arid in the north, and to humid and sub-humid in the south (Di Castri & Hajek 1976); the annual mean precipitation varies from 50 mm in the north to 500 mm in the south (Moreira-Muñoz 2011), although in the Andes range southwards from Santiago it may reach 1000 mm. The rain is brought by frontal systems which originate in the Pacific Ocean and enter the continent from the South-West. The Coastal Range (with North-South orientation) acts as a barrier to the cloud masses and as a result the sites to the West of the range present a lower aridity index than those immediately to the East (Di Castri & Hajek 1976).

Quillaja saponaria, commonly named Quillay, is an endemic Chilean tree found from the Coquimbo Region to the Bío-Bío Region (Arauco Province), approximately between 31° and 38° south (García & Ormazábal 2008, Prehn *et al.* 2003). It grows from sea level to 1600 m a.s.l., preferably in dry areas which are poor in nutrients. The study area covered the whole distribution of *Q. saponaria*.

Field surveys

We visited 39 sites where *Q. saponaria* grows naturally, within the range of the species (Fig. 1, Table 1), in four field campaigns between August 2011 and April 2012. In each of the 39 sites visited, three sampling transects were established, each 400 m long. In each transect five plots were established, one every 85 m, giving a total of 15 sampling units per site. The plots were rectangular (20 × 5 m; 100 m^2). In each plot all the woody species were recorded, including arborescent cacti. The abundance of each species was expressed as a percentage of the sampled area (Mueller-Dombois & Ellenberg 1974). The specific names followed the nomenclature proposed by Zuloaga *et al*. (2008), and in a few cases the nomenclature of Marticorena & Quezada (1985). In every case, the record included the botanical family, the chorological characterisation as an endemic species (geographical range restricted to Chile), element of the flora of the southern cone (native) and/or cosmopolitan species (adventitious), and the life form (tree or shrub).

Patterns of richness and diversity

The richness of species (number of species) was determined for each site, and the alpha diversity was calculated using the Shannon-Wiener index (H´) and the Simpson's index (D) – the former attributes greater weight to rare species whereas in the latter rare species have little influence (Felfili & Felfili 2001). It is important to consider that these two indices are not collinear.

A Principal Coordinates Analysis (PCoA, Podani & Miklós 2002) was done to determine the similarity patterns between the species composition and abundance of the sites, using the Bray-Curtis similarity index (Podani & Miklós 2002). For this purpose, the sites were grouped according to the vegetation matrix adjacent to each sampling locality, with three types of matrix being defined: 1) native forest, when the sampled community was surrounded by a natural forest or matorral community; 2) commercial forestry plantations, when the community was surrounded by a commercial forestry matrix, principally plantations of *Pinus radiata*; and 3) agricultural use when the community was surrounded by farm crops. These analyses were done using the PAST 3.x software (Hammer *et al*. 2001).

To assess if the richness and diversity of the communities is influenced by climatic variables, the values of annual mean temperature and annual precipitation were obtained from Worldclim (Hijmans *et al.* 2005, Available: http://www.worldclim.org/) for each locality visited. Additionally, the De Martonne aridity index was calculated (*sensu* Mercado-Mancera *et al.* 2010, Wang & Takahashi 1999) for each site. This aridity index (AI) relates annual or monthly precipitation, as appropriate, with the average annual or monthly temperature. The value obtained allows classifying the plant community or site under study as desert, grassland or forest, depending on the degree of aridity (Wang &

Takahashi 1999). The index was obtained as follows:

$$AI=\frac{P}{T+10} \qquad \text{(Wang \& Takahashi 1999)}$$

Where P is the annual precipitation in millimetres and T the average annual temperature in Celsius degrees.

To detect spatial patterns in the variation of the number of species, alpha diversity, and composition of the communities (as summarized by coordinate axes 1 and 2 of the PCoA), multiple regression analyses (stepwise) of these variables were done with the spatial and climate variables of the sites. The variables included as predictors were latitude, longitude, the De Martonne aridity index, altitude, type of forestry matrix, annual mean temperature and annual precipitation. The parameters used for the analysis were: Probability to enter = 0.250, Probability to leave = 0.100, Direction = Forward, Rules = Combine. Subsequently, the variables identified as significant, were incorporated to a multiple regression model. These analyses were done with the JMP 8.0 SAS Institute Inc., Cary, NC, 1989-2007.

Analysis of phylogenetic diversity

For each site visited, we calculated four abundance-based phylogenetic metrics (Vamosi *et al.* 2009, Webb *et al.* 2008, Webb *et al.* 2002): 1) mean phylogenetic distance (MPD), 2) mean nearest taxon phylogenetic distance (MNTD), 3) net related index (NRI) and 4) nearest taxon index (NTI). MPD and MNTD measure the average phylogenetic distance among pairs of individuals drawn at random from a sample, where MPD includes conspecifics and MNTD considers the closest non-conspecific relative (Vamosi *et al.* 2009; Webb *et al.* 2008). NRI is a calculation of the effect size of MPD relative to a null model and indicates whether taxa in a sample are more phylogenetically clustered (positive NRI) or even (negative NRI) than expected at random; NTI quantifies the extent of terminal clustering, that is, intrafamilial clustering (positive NTI also indicates phylogenetic clustering, while negative values represent phylogenetic uniformity).

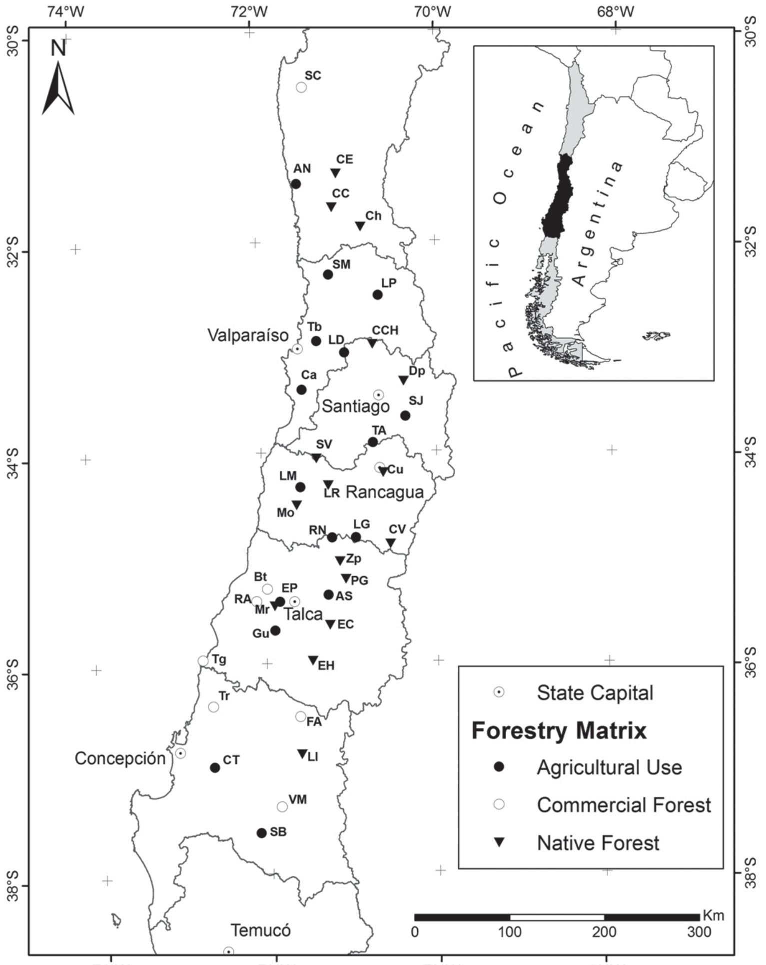

Figure 1: Location of the sampled sites. Different symbols indicate the type of vegetation matrix adjacent to each site. The name codes are listed in Table 1. / Localización de los sitios muestreados. Diferentes símbolos indican el tipo de matriz de la vegetación adyacente a cada sitio. Los códigos de nombres se enumeran en la Tabla 1.

Table 1. Geographical and climatic information for the 39 sampled sites of *Q. saponaria*. The order of localities follows the North - South orientation of the States and within each State the sites are listed in alphabetical order. / Información geográfica y climática para los 39 sitios muestreados de *Q. saponaria*. El orden de las localidades sigue la orientación Norte - Sur de las Regiones y dentro de cada Región los sitios se enumeran en orden alfabético.

State	Site	Site code	Geographical Coordinates (Lat. S / Long. W)	Vegetation Matrix^1	Altitude^2 (m a.s.l.)	Annual Precipitation^3 (mm)	Annual Mean Temperature^3 (°C)	De Martonne aridity index (AI)
Coquimbo Region (Región de Coquimbo)	Angostura	AN	31°27’00” / 71°31’32”	AU	341	186	15.2	7.4
	Chillepin	Ch	31°52’01” / 70°49’34”	NF	749	233	14.7	9.4
	Cuesta El Espino	CE	31°21’28” / 71°05’26”	NF	1,413	211	10.2	10.4
	Cuesta Los Cristales	CC	31°40’43” / 71°08’41”	NF	669	223	14.4	9.1
	Santa Cristina	SC	30°32’02” / 71°26’41”	CF	200	120	15.6	4.7
Valparaíso Region (Región de Valparaíso)	Casablanca	Ca	33°24’35” / 71°31’02”	AU	226	545	15.2	21.6
	Cuesta La Dormida	LD	33°03’45” / 71°01’49”	AU	894	381	13.2	16.4
	Los Patos	LP	32°31’08” / 70°38’19”	AU	1,205	296	15.0	11.8
	Santa Marta	SM	32°19’07” / 71°11’35”	AU	200	273	17.6	9.9
	Tabolango	Tb	32°56’52” / 71°20’33”	AU	213	446	14.2	18.4
Metropolitan Region of Santiago (Región Metropolitana de Santiago)	Camino a La Disputada	Dp	33°20’15” / 70°21’54”	NF	1,642	511	10.7	24.7
	Cuesta Chacabuco	CCH	32°59’06” / 70°42’40”	NF	995	314	14.3	12.9
	San José de Maipo	SJ	33°40’22” / 70°20’45”	AU	1,157	658	11.9	30.0
O’Higgins Region (Región de O’Higgins)	Chorro de la Vieja	CV	34°53’05” / 70°32’16”	NF	1,283	989	10.0	49.5
	Coya	Cu	34°12’19” / 70°36’33”	NF	904	796	12.2	35.9
	Cuesta San Vicente	SV	34°03’50” / 71°22’11”	NF	277	456	15.9	17.6
	Fundo La Rosa	LR	34°19’10” / 71°14’28”	NF	390	519	16.3	19.7
	La Gatera	LG	34°49’12” / 70°56’03”	AU	449	903	13.6	38.3
	Los Maitenes	LM	34°20’05” / 71°33’33”	AU	189	614	15.9	23.7
	Rinconada de Navarro	RN	34°49’09” / 71°12’34”	AU	275	829	13.7	35.0
	Sector Molineros	Mo	34°30’18” / 71°36’34”	NF	343	708	14.2	29.2
	Túnel Angostura	TA	33°55’12” / 70°43’09”	AU	598	519	15.4	20.4
Maule Region (Región del Maule)	Astillero	AS	35°21’48” / 71°15’48”	AU	303	923	13.4	39.4
	Camino a Cerro Gupo	Gu	35°41’20” / 71°53’28”	AU	390	981	12.6	43.4
	Cuesta Batuco	Bt	35°17’46” / 71°58’14”	CF	267	924	13.0	40.2
	El Colorado	EC	35°38’53” / 71°15’12”	NF	473	1,072	12.4	47.9
	El Morro	Mr	35°27’33” / 71°53’25”	NF	258	855	14.5	34.9
	Fundo El Peral	EP	35°25’10” / 71°49’40”	AU	81	832	14.3	34.2
	Potrero Grande	PG	35°12’51” / 71°03’41”	NF	491	973	12.4	43.4
	Risco Afuera	RA	35°24’42” / 72°05’56”	CF	245	1,021	13.0	44.4
	Tregualemu	Tg	35°57’25” / 72°44’48”	CF	10	816	13.6	34.6
	Vuelta El Horno	EH	35°59’07” / 71°28’01”	NF	439	1,200	13.2	51.7
	Zapallar	Zp	35°02’48” / 71°07’26”	NF	288	845	13.6	35.8

State	Site	Site code	Geographical Coordinates (Lat. S / Long. W)	Vegetation Matrix[1]	Altitude[2] (m a.s.l.)	Annual Precipitation[3] (mm)	Annual Mean Temperature[3] (°C)	De Martonne aridity index (AI)
Bío-Bío Region (Región del Bío-Bío)	Cuesta Tomeco	CT	36°58'29" / 72°39'18"	AU	205	1,301	12.4	58.1
	La Invernada	LI	36°52'11" / 71°37'20"	NF	808	1,371	9.7	69.6
	San Fabián de Alico	FA	36°30'52" / 71°37'37"	CF	450	1,352	11.9	61.7
	Santa Bárbara	SB	37°36'37" / 72°07'42"	AU	200	1,357	12.8	59.5
	Trehuaco	Tr	36°23'56" / 72°38'44"	CF	143	1,070	13.5	45.5
	Villa Mercedes	VM	37°22'08" / 71°52'33"	CF	406	1,374	11.3	64.5

[1] Type of vegetation matrix: Agricultural Use (AU), Commercial Forest (CF) and Native Forest (NF). / Tipo de matriz vegetacional: Uso Agrícola (AU), Plantación Forestal (CF) y Bosque Nativo (NF).

[2] The values of altitude (m a.s.l.) were extracted from "Shuttle Radar Topography Mission" (Rodríguez *et al*. 2005, Farr *et al*. 2007). / Los valores de altitud (msnm) fueron obtenidos del "Shuttle Radar Topography Mission" (Rodríguez *et al.* 2005, Farr *et al*. 2007).

[3] The values of Annual Precipitation (mm) and Annual Mean Temperature (°C) extracted from Worldclim (Hijmans *et al.* 2005). / Los valores de precipitación anual (mm) y temperatura media anual (°C) fueron extraídos de Worldclim (Hijmans *et al.* 2005).

To estimate these metrics, we compiled a full species list based on The Angiosperm Phylogeny Group (2009) classification for the 60 taxa sampled in the 39 sites. Then, species were classified by genus and family and we used the Phylomatic function of Phylocom 4.1 (Webb *et al*. 2008) and a maximally resolved supertree of angiosperms (R20100701 available at http://www.phylodiversity.net) to construct a regional phylogeny from the species list. The 'bladj' algorithm was used to estimate branch lengths in the phylogeny and the node ages provided by Wikström *et al*. (2001) were used. Then, we used the Construct function of Phylocom 4.1 to calculate the phylogenetic metrics for each sampled site. The switch '-a' was used to weight phylogenetic distances by taxa abundances.

To detect spatial patterns in the variation of the phylogenetic diversity indices of the sites, multiple regression analyses (stepwise) were performed using the same set of spatial and climate variables and the same specifications previously explained for the analyses of richness diversity and composition of the communities, using the JMP 8.0 SAS Institute Inc., Cary, NC, 1989-2007.

RESULTS

Flora

Analysis of the flora resulted in the presence of 59 taxa (species level or lower), distributed among 28 families. In terms of life forms, we distinguished 22 trees and 37 shrubs. The most frequent families were Fabaceae with 10 taxa, followed by Asteraceae with 7 taxa, Myrtaceae with 4 taxa and Anacardiaceae, Nothofagaceae and Solanaceae with 3 taxa each. 28 taxa were native, 27 were endemic to Chile and 5 were adventitious (see Table 2).

Patterns of richness and diversity

The lowest alpha diversities were found in the localities of Santa Bárbara (SB) in the Bío-Bío Region, and Tregualemu (Tg), Fundo El Peral (EP) and Risco Afuera (RA) in the Maule Region. The highest alpha diversities were found in the populations of Cuesta Los Cristales (CC) in the Coquimbo Region, and Potrero Grande (PG), El Colorado (EC) and Cuesta Batuco (Bt) in the Maule Region (see Table 3), surrounded by forest matrix. The mean species richness per site was seven, with a maximum of 14 species in Santa Marta (SM, Valparaíso Region) and a minimum of 3 species at sites of Cuesta Chacabuco (CCH, Metropolitan Region of Santiago), Santa Barbara (SB) and Cuesta Tomeco (CT), both in the Bío-Bío Region. The average of the Shannon-Wiener index for all sites was (mean ± standard deviation) 0.558 ± 0.139 and for the Simpson index the average was 0.320 ± 0.108.

The Principal Coordinates Analysis (PCoA) suggested an influence of the vegetation matrix surrounding the sites on the composition of the sampled communities (see Fig. 2). The coordinate axes 1 and 2, explained 16.4 and 12% of the total variation, respectively. The sites where the surrounding matrix was native forest were grouped mainly in the negative part of coordinate axis 2, although the Cuesta Los Cristales (CC), Cuesta Chacabuco (CCH) and El Morro (Mr) sites separated from this group. In contrast, sites where the surrounding matrix was agricultural land clustered mostly in the negative part of coordinate axis 1. Finally, the sites where the matrix was commercial forest showed the greatest dispersion (see Fig. 2).

The values of the De Martone aridity index were correlated with both latitude and longitude ($r = 0.96$; $p < 0.0001$) with a Equation: 3D, Paraboloid (Durbin-Watson Statistic: 1.8280, Passed), showing that the aridity diminishes towards the south and west (see Fig. 3).

The results of the stepwise regression models for the diversity and composition metrics of the 39 communities as a function of spatial and climate variables are shown in Table 4. The model for species richness was marginally significant ($p = 0.079$), with type of vegetation matrix being the only explanatory variable included in the model. Species richness tended to be lower at sites surrounded by an agricultural matrix than at sites surrounded by commercial forest plantations or native forest.

In the case of the Shannon-Wiener diversity index the model indicated a significant effect of the vegetation matrix ($p = 0.012$) with sites adjacent to native forests being more diverse than sites adjacent to an agricultural or commercial forest plantation matrix. The effect of latitude was also significant ($p = 0.046$) with a decrease in diversity with increasing latitude. In contrast, for the Simpson's index a marginally significant ($p = 0.089$) decrease in diversity with longitude was detected (from East to West).

For the scores on coordinate axes 1 and 2 from the PCoA analysis (which summarize the similarity relationships among sites in terms of composition) the resulting models were highly significant ($p < 0.0001$ and $p = 0.0017$, respectively). In the case of coordinate 1 there was a significant effect of the adjacent vegetation matrix ($p < 0.0001$), and altitude ($p = 0.003$). Coordinate 2 was significantly associated with latitude ($p = 0.004$) and annual mean temperature ($p = 0.001$).

Patterns of phylogenetic diversity

The Mean Phylogenetic Distance (MPD) was on average 27.8 million years (myr) with a standard deviation of 8.52 myr. The maximum value was found in Potrero Grande (PG) with 42.4 myr, and the minimal value was obtained in San José de Maipo (SJ) with 11.6 myr (see Table 3). Although a significant pattern related with the surrounding matrix was not detected, the highest MPD values tended to occur in the localities surrounded by a matrix of native forest or forestry plantation, and the lowest values were found in sites surrounded by an agricultural matrix.

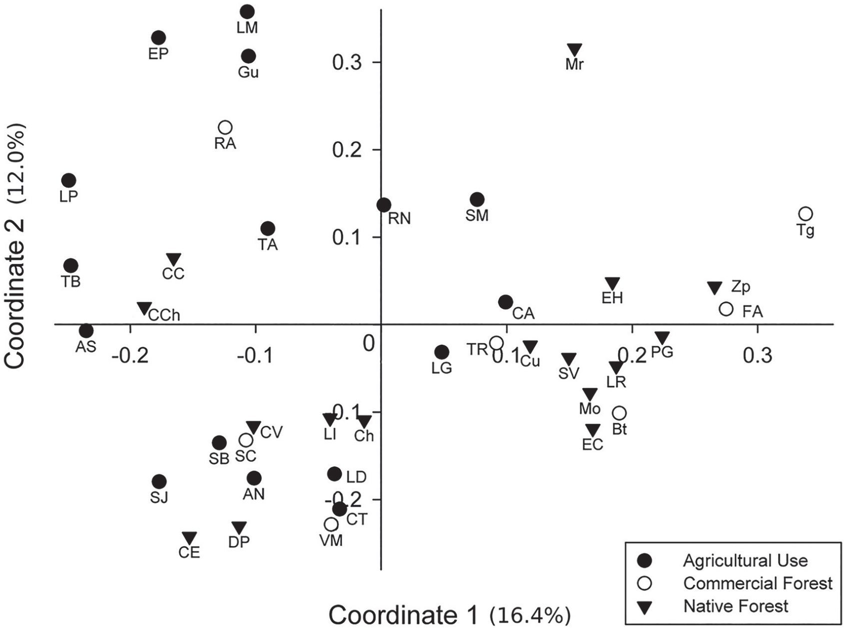

Figure 2: Principal Coordinates Analysis based on the Bray-Curtis similarity index among sampled sites. In parentheses the percentage of explained variance is shown for each of the coordinate axes. / Análisis de Coordenadas Principales basado en el índice de similitud de Bray-Curtis de los sitios. En paréntesis aparece el porcentaje de la varianza que es explicado por cada eje de coordenadas.

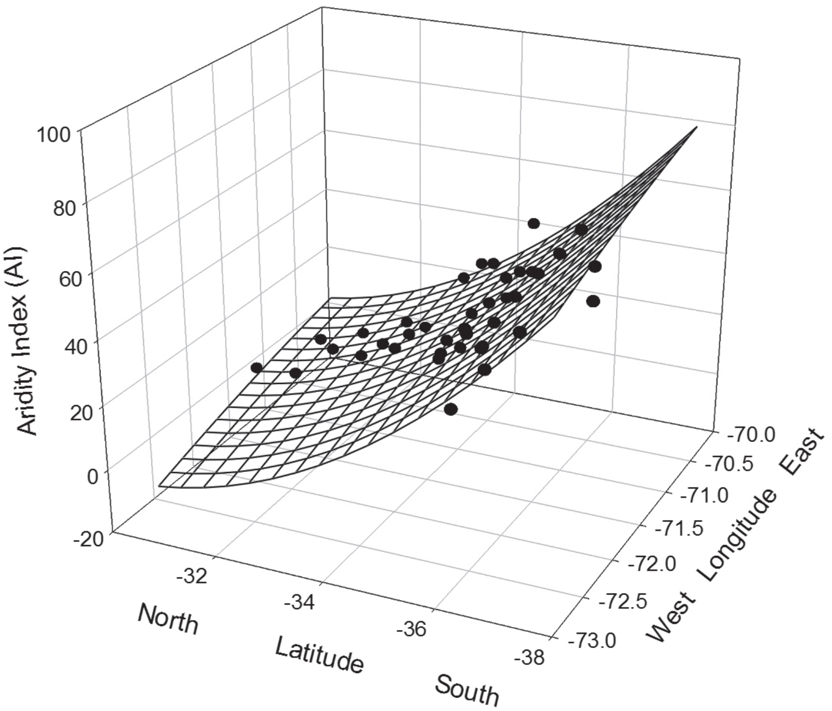

Figure 3: Correlation between the De Martonne aridity index (AI) with latitude and longitude. / Correlación entre el índice de aridez de De Martonne (AI) versus Latitud y Longitud.

TABLE 2. Composition, growth habit, number of sites where each species was collected and origin of woody species associated with the sites of *Q. saponaria*. Growth habit and origin were extracted from Zuloaga *et al*. (2008). / Listado de especies, hábito de crecimiento, número de sitios donde se encontró y origen de las especies leñosas asociadas con los sitios de *Q. saponaria*. Hábito de crecimiento y origen se extrajeron de Zuloaga *et al*. (2008).

DIVISION	CLASS	GROWTH HABIT	NUMBER OF SITES	ORIGIN
FAMILY	SPECIES			
GNETOPHYTA	GNETOPSIDA			
Ephedraceae	*Ephedra chilensis* C. Presl	Shrub	2	Native
PINOPHYTA	PINOPSIDA			
Cupressaceae	*Austrocedrus chilensis* (D. Don) Pic.Serm. & Bizzarri	Tree	1	Native
Pinaceae	*Pinus radiata* D.Don	Tree	3	Adventitious
MAGNOLIPHYTA	MAGNOLIOPSIDA			
Anacardiaceae	*Lithrea caustica* (Molina) Hook. & Arn.	Tree	21	Endemic
	Schinus areira L.	Tree	2	Native
	Schinus polygamus (Cav.) Cabrera var. *polygamus*	Shrub	8	Native
Asteraceae	*Baccharis linearis* (Ruiz & Pav.) Pers. ssp. *linearis*	Shrub	17	Native
	Flourensia thurifera (Molina) DC.	Shrub	1	Endemic
	Haplopappus canescens (Phil.) Reiche	Shrub	3	Endemic
	Haplopappus taeda Reiche	Shrub	1	Endemic
	Haplopappus velutinus J. Remy	Shrub	2	Native
	Proustia cuneifolia D. Don var. *cuneifolia*	Shrub	1	Native
	Tessaria absinthioides (Hook. & Arn.) DC.	Shrub	1	Native
Berberidaceae	*Berberis actinacantha* Mart.	Shrub	1	Endemic
	Berberis chilensis Gillies ex Hook. & Arn. var. *chilensis*	Shrub	4	Endemic
Buddlejaceae	*Buddleja globosa* Hope	Shrub	2	Native
Cactaceae	*Trichocereus chiloensis* (Colla) Britton & Rose ssp. *chiloensis*	Shrub	6	Endemic
Calceolariaceae	*Calceolaria dentata* Ruiz & Pav. ssp. *dentata*	Shrub	1	Native
Campanulaceae	*Lobelia excelsa* Bonpl.	Shrub	4	Endemic
	Lobelia tupa L.	Shrub	3	Endemic
Celastraceae	*Maytenus boaria* Molina	Tree	7	Native
Elaeocarpaceae	*Aristotelia chilensis* (Molina) Stuntz	Shrub	11	Native
Ericaceae	*Gaultheria angustifolia* (Lindl.) Teillier	Shrub	1	Native
Fabaceae	*Acacia caven* (Molina) Molina	Tree	21	Native
	Acacia dealbata Link	Tree	2	Adventitious
	Adesmia argentea Meyen	Shrub	4	Endemic
	Teline monspessulana (L.) K. Koch	Shrub	3	Adventitious
	Geoffroea decorticans (Gillies ex Hook. & Arn.) Burkart	Tree	1	Native
	Otholobium glandulosum (L.) J.W. Grimes	Tree	2	Endemic
	Prosopis chilensis (Molina) Stuntz emend. Burkart var. *chilensis*	Tree	1	Native
	Senna cumingii (Hook. & Arn.) H.S. Irwin & Barneby var. *alcaparra* (Phil.) H.S. Irwin & Barneby	Shrub	1	Endemic
	Senna cumingii (Hook. & Arn.) H.S. Irwin & Barneby var. *cumingii*	Shrub	1	Endemic
	Sophora macrocarpa Sm.	Tree	2	Endemic
Lamiaceae	*Lepechinia chamaedryoides* (Balb.) Epling	Shrub	4	Endemic
Lauraceae	*Cryptocarya alba* (Molina) Looser	Tree	12	Endemic
	Laurus nobilis L.	Shrub (Tree)	1	Adventitious

Division	Class	Growth habit	Number of sites	Origin
Family	Species			
Monimiaceae	*Peumus boldus* Molina	Tree	21	Endemic
Myrtaceae	*Eucalyptus globulus* Labill.	Tree	1	Adventitious
	Luma apiculata (DC.) Burret	Shrub (Tree)	4	Native
	Luma chequen (Molina) A. Gray	Shrub	4	Native
	Ugni candollei (Barnéoud) O. Berg	Shrub	1	Endemic
Nothofagaceae	*Nothofagus dombeyi* (Mirb.) Oerst.	Tree	3	Native
	Nothofagus macrocarpa (A. DC.) F.M. Vázquez & R.A. Rodr.	Tree	2	Endemic
	Nothofagus obliqua (Mirb.) Oerst. ssp. *obliqua*	Tree	1	Native
Onagraceae	*Fuchsia lycioides* Andrews	Shrub	1	Endemic
	Fuchsia magellanica Lam.	Shrub	1	Native
Polygonaceae	*Muehlenbeckia hastulata* (Sm.) I.M. Johnst. var. *hastulata*	Shrub	7	Native
Proteaceae	*Gevuina avellana* Molina	Tree	1	Native
	Lomatia hirsuta (Lam.) Diels ssp. *obliqua* (Ruiz & Pav.) R.T. Penn.	Tree	1	Native
Quillajaceae	*Quillaja saponaria* Molina	Tree	39	Endemic
Rhamnaceae	*Colletia hystrix* Clos	Shrub	8	Native
	Retanilla trinervia (Gillies & Hook.) Hook. & Arn.	Shrub	9	Endemic
Rosaceae	*Kageneckia oblonga* Ruiz & Pav.	Tree	10	Endemic
Salicaceae	*Azara dentata* Ruiz & Pav.	Shrub	2	Endemic
	Azara integrifolia Ruiz & Pav.	Shrub	2	Endemic
Solanaceae	*Cestrum parqui* L'Hér.	Shrub	8	Native
	Fabiana imbricata Ruiz & Pav.	Shrub	2	Endemic
	Solanum crispum Ruiz & Pav.	Shrub	1	Native
Zygophyllaceae	*Porlieria chilensis* I.M. Johnst.	Tree	2	Endemic

The Mean Nearest Taxon Phylogenetic Distance (MNTD) showed an average of 26.1 myr with a standard deviation of 8.37 myr. The Risco Afuera (RA) site showed the maximum value with 46.6 myr, and the Santa Cristina (SC) site had the minimum value of 8.1 myr (see Table 3). In this case, the localities near to the forestry plantation matrix have the highest MNTD value (mean of 30.3 myr), and the localities near to native forest or agricultural matrix showed a MNTD mean of 25.6 myr and 24.7 myr, respectively.

The average Net Related Index (NRI) was 0.07 with a standard deviation of 1.07. The sites with the maximum values were San José de Maipo (SJ) and Santa Cristina (SC), with positive values of 2.51 and 1.99, respectively, indicating phylogenetic clustering at these sites. The minimum value was found in Risco Afuera (RA), with -2.15, indicating phylogenetic evenness (see Table 3). The localities near to the forestry plantation matrix showed the lowest NRI value.

For the Nearest Taxon Index (NTI) the average value was 0.05 with a standard deviation of 1.05. The higher positive values (indicating phylogenetic clustering) were found in Santa Cristina (SC) and San José de Maipo (SJ) (2.27 and 2.10, respectively). The largest negative value was found in Risco Afuera (RA) with -2.27 (see Table 3), indicating phylogenetic evenness.

The results of the stepwise multiple regression models calculated for the four metrics of phylogenetic diversity are shown in Table 4. The only explanatory variables significantly correlated with these metrics were altitude and latitude: MPD decreased and NTI increased with altitude, indicating less phylogenetic diversity and higher phylogenetic clustering at higher altitudes, while MNTD decreased and NRI increased with increasing latitude, indicating less diversity and higher clustering in the north in comparison to the south (Table 4).

Table 3. Shannon-Wiener (H') and Simpson (D) indexes (alpha diversity), Number of species, Coordinates 1 & 2 of the PCoA and Index of Phylogenetic Diversity: Mean Phylogenetic Distance (MPD), Mean Nearest Taxon Phylogenetic Distance (MNTD), Net Related Index (NRI) and Nearest Taxon Index (NTI) of sites of *Q. saponaria*. The names of sites are listed in Table 1. / Índices de diversidad alfa de Shannon-Wiener (H') y Simpson (D), Número de especies, Coordenadas 1 y 2 de PCoA e Índices de Diversidad Filogenética: Distancia Filogenética Promedio (MPD), Distancia Filogenética Promedio al Taxón más cercano (MNTD), Índice de Relación Neta (NRI) e Índice del Taxón más cercano (NTI) de los sitios de *Q. saponaria*. Los nombres de los sitios están listados en la Tabla 1.

Site code	Shannon-Wiener (H')	Simpson (D)	Number of species	Coord 1	Coord 2	MPD	MNTD	NRI	NTI
AN	0.453	0.342	4	-0.101	-0.175	27.5	34.7	-0.04	-0.36
Ch	0.461	0.346	7	-0.014	-0.019	21.6	21.6	0.83	0.53
CE	0.716	0.208	10	-0.153	-0.242	21.8	13.8	1.64	1.69
CC	0.936	0.108	11	-0.166	0.076	27.5	14.7	1.43	1.71
SC	0.653	0.283	7	-0.108	-0.132	14.6	8.1	1.99	2.27
Ca	0.651	0.231	7	0.099	0.026	38.6	32.6	-0.88	-0.87
LD	0.503	0.379	7	-0.037	-0.171	22.4	23.7	0.59	0.29
LP	0.488	0.354	4	-0.249	0.165	16.9	19.2	1.08	1.00
SM	0.536	0.325	14	0.076	0.143	33.7	24.7	-0.18	-0.34
Tb	0.460	0.347	6	-0.247	0.067	16.7	17.4	1.37	1.10
Dp	0.613	0.264	8	-0.113	-0.230	23.6	20.3	0.92	0.69
CCH	0.439	0.368	3	-0.189	0.021	17.4	21.3	1.02	1.04
SJ	0.629	0.251	7	-0.177	-0.179	11.6	10.3	2.51	2.10
CV	0.598	0.291	5	-0.102	-0.116	15.9	20.4	1.18	0.94
Cu	0.604	0.303	9	0.119	-0.024	32.1	30.2	-0.34	-0.80
SV	0.703	0.238	8	0.150	-0.038	31.4	30.0	-0.01	-0.21
LR	0.652	0.240	12	0.187	-0.047	33.7	26.2	-0.17	-0.49
LG	0.531	0.318	8	0.048	-0.032	29.1	25.6	0.06	-0.06
LM	0.604	0.295	7	-0.107	0.358	30.9	25.9	-0.24	0.15
RN	0.472	0.337	9	0.002	0.137	30.6	25.8	-0.23	-0.19
Mo	0.540	0.307	9	0.166	-0.078	36.3	32.6	-0.79	-1.11
TA	0.538	0.308	6	-0.090	0.110	25.6	22.6	0.35	0.47
AS	0.528	0.318	4	-0.235	-0.007	16.7	17.6	-0.04	-0.36
Gu	0.567	0.319	9	-0.106	0.307	32.1	24.4	-0.33	0.02
Bt	0.741	0.200	13	0.190	-0.101	41.1	32.8	-1.04	-1.80
EC	0.761	0.193	9	0.169	-0.119	39.4	29.2	-0.84	-0.73
Mr	0.624	0.254	8	0.154	0.316	39.8	31.1	-1.06	-0.77
EP	0.350	0.513	6	-0.178	0.328	21.9	25.7	-0.13	0.13
PG	0.815	0.153	11	0.224	-0.013	42.4	29.6	-1.07	-1.16
RA	0.394	0.578	8	-0.124	0.225	28.7	46.6	-2.15	-2.27
Tg	0.319	0.624	6	0.338	0.127	22.8	40.4	-1.31	-1.31
EH	0.528	0.318	4	0.184	0.049	39.2	40.8	-1.43	-0.91
Zp	0.419	0.419	10	0.266	0.044	35.9	34.7	-1.22	-1.34
CT	0.415	0.412	3	-0.033	-0.211	24.0	35.0	-0.08	-0.08
LI	0.410	0.425	10	-0.041	-0.107	15.8	16.1	1.35	1.02
FA	0.574	0.272	4	0.275	0.018	40.2	34.5	-1.19	-0.28
SB	0.279	0.523	3	-0.129	-0.135	26.0	30.9	-0.70	0.24
Tr	0.715	0.209	9	0.092	-0.021	31.8	22.1	0.20	0.42
VM	0.554	0.293	5	-0.040	-0.228	27.0	22.1	0.20	0.42
Average	0.558	0.320	7.4			27.8	26.1	0.07	0.05
Standard Deviation	0.139	0.108	2.8			8.52	8.37	1.07	1.05
Maximum value	0.936	0.624	14			42.4	46.6	2.51	2.27
Minimal value	0.279	0.108	3			11.6	8.1	-2.15	-2.27

Table 4. Results of the multiple regression analysis of the Number of species, Shannon-Wiener (H') and Simpson (D) index (alpha diversity), Coordinates 1 & 2 of the PCoA and Index of Phylogenetic Diversity (MPD, MNTD, NRI and NTI), on spatial and climate variables of *Q. saponaria* sites. Values in boldface are significant (P < 0.05). / Resultados del análisis de regresión múltiple para el número de especies, índices de diversidad alfa de Shannon-Wiener (H') y Simpson (D), coordenadas 1 y 2 del PCoA y de los índices de diversidad filogenética (MPD, MNTD, NRI y NTI), respecto de variables espaciales y climáticas de los sitios de *Q. saponaria*. Valores en negritas son significativos (P<0,05).

	Estimate	Standard Error	*t*	*P (P Model)*[1]
Number of species				(0.0792)
Intercept	7.5788	0.4411	17.18	**< 0.0001**
Forestry Matrix (Agricultural Use ≠ Commercial Forest and Native Forest)	-0.7962	0.4411	-1.81	0.0792
Shannon-Wiener				**(0.0120)**
Intercept	1.3745	0.3998	3.44	**0.0015**
Forestry Matrix (Native Forest ≠ Agricultural Use and Commercial Forest)	-0.0527	0.0206	3.44	**0.0147**
Latitude	-0.0240	0.0116	2.07	**0.0460**
Simpson				**(0.0284)**
Intercept	-3.3499	2.0987	-1.60	0.1192
Forestry Matrix (Commercial Forest ≠ Native Forest and Agricultural Use)	-0.0244	0.0177	-1.38	0.1768
Longitude	-0.0513	0.0294	-1.75	0.0894
Coord 1				**(< 0.0001)**
Intercept	5.6820	3.8405	1.48	0.1482
Forestry Matrix (Commercial Forest ≠ Native Forest and Agricultural Use)	-0.0930	0.0208	-4.46	**<0.0001**
Latitude	-0.0253	0.0155	-1.86	0.0709
Longitude	0.0902	0.0560	1.61	0.1161
Altitude	-0.0002	7.673e-5	-3.21	**0.0029**
Coord 2				**(0.0017)**
Latitude	-1.8028	0.5913	-3.05	**0.0043**
Annual Mean Temperature	0.0538	0.0140	3.84	**0.0005**
MPD				**(0.0025)**
Intercept	33.8793	1.9839	17.08	**< 0.0001**
Forestry Matrix (Agricultural Use)	-3.2293	1.6356	-1.97	0.0563
Forestry Matrix (Commercial Forest)	-1.3775	2.1445	-0.64	0.5248
Altitude	-0.0124	0.0033	-3.75	**0.0006**
MNTD				**(0.0011)**
Intercept	-269.6311	152.7879	-1.94	0.0603
Latitude	-2.2294	0.9043	-2.47	**0.0187**
Longitude	-3.2278	2.4258	-1.33	0.1919
Annual Mean Temperature	1.1460	0.7469	1.53	0.1339
NRI				**(0.0002)**
Intercept	12.5820	5.8710	2.14	**0.0396**
Forestry Matrix (Agricultural Use)	0.3458	0.1920	1.80	0.0809
Forestry Matrix (Commercial Forest)	-0.0714	0.2546	-0.28	0.7809
Latitude	0.3119	0.1202	2.59	**0.0141**
Annual Mean Temperature	-0.1638	0.1355	-1.21	0.2353
Altitude	0.0008	0.0006	1.34	0.1902
NTI				**(0.0021)**
Intercept	4.9827	3.0793	1.62	0.1149
Forestry Matrix (Agricultural Use)	0.3170	0.1990	1.59	0.1204
Forestry Matrix (Commercial Forest)	0.0190	0.2595	0.07	0.9419
Latitude	0.1618	0.0869	1.86	0.0714
Altitude	0.0013	0.0004	2.99	**0.0051**

[1] Value of P of the model (Standard Least Squares) produced after the multiple regression analysis. / Valor de P del modelo (Estándar de Mínimos Cuadrados) realizado *a posteriori* del análisis de regresión múltiple.

DISCUSSION

In this study, we have explored the patterns of richness, diversity and phylogenetic diversity of woody plant communities in the sclerophyllous forests of Chile across their whole native range. Furthermore, we evaluated whether these patterns can be explained by geographic, climatic and human disturbance variables.

In general, the species found in this study correspond to the woody flora defined historically as components of sclerophyllous forest communities (Amigo & Flores-Toro 2012, García & Ormazábal 2008, Hechenleitner *et al.* 2005). The presence of species belonging to genera such as *Nothofagus, Lomatia* or *Austrocedrus* at some sites was atypical for these types of communities. This occurred particularly at some of the southernmost sites, located in areas that are probably transitional towards more humid types of forest (Gajardo 1994, Luebert & Pliscoff 2004).

The stepwise multiple regression models allowed determining the relevance of the different spatial, climate and disturbance variables (*i.e.* the type of the surrounding vegetation matrix) on the patterns of richness, diversity and composition of the sites. Interestingly, the type of vegetation matrix was found to have a marginally significant effect on species richness and a significant effect on the Shannon-Wiener diversity index and on the scores of the first axis of the Principal Coordinates Analysis, which summarizes the similarity relationships among sites in terms of composition. These results indicated that sites surrounded by the same type of vegetation matrix also tended to be more similar in their species composition and also that the diversity of the communities was in general lower, intermediate and higher at sites surrounded by agricultural, commercial forestry plantation and natural forest matrices, respectively.

For example, the low alpha diversity found in Santa Bárbara (SB) in the Bío-Bío Region, and Tregualemu (Tg), Fundo El Peral (EP) and Risco Afuera (RA) in the Maule Region, may be related to the surrounding vegetation matrix, which in the cases of SB and EP is agricultural land, and in the RA and Tg communities is commercial forestry plantation of *Pinus radiata* D. Don. Furthermore, the clear separation of the Risco Afuera (RA) community from the other sites where the adjacent matrix was commercial forest is explained by the very high abundance of *Pinus radiata* at this site. This pine covered 60% of the sampled area and defined the community, evidencing the colonising ability of the species, reported previously by Gómez *et al*. (2011), who found that in small fragments of native forest (less than or equal to 20 hectares, as is the case with the RA site), colonisation by seeds of *P. radiata* from the adjacent matrix was higher than in larger fragments.

A reduction in the diversity of communities frequently results from disturbance caused by human activity (Hobbs & Huenneke 1992). Furthermore, as described by Gómez *et al*. (2011), *P. radiata* plantations may be a source of propagation into natural communities. This effect may be seen as an increase in the diversity of the community suffering the invasion, but also as a threat, since the presence of this species increases competition for soil (Jorquera-Jaramillo 2008). In addition, as mentioned by Figueroa *et al*. (2004), pasture regimes and propagation pressure result in a threat by exotic species to native plant communities. This supports the idea that the surrounding matrix affects the number of species in a location, and therefore the alpha diversity of the communities, since transformation to commercial forestry plantations or agriculture leads to a reduction in the diversity of the adjacent remaining natural communities (Hobbs & Huenneke 1992).

A different case is probably represented by the Cuesta Chacabuco (CCH) site, which is surrounded by native forest but showed a low diversity, with only three tree species recorded (*i.e.*, *Acacia caven*, *Lithrea caustica* and *Quillaja saponaria*). This site is situated in the northern part of the study region in a transitional zone to more arid vegetation types. Also, the unusual composition of this locality is related to its classification as "spiny open woodland" (bosque espinoso abierto), a type of sclerophyllous forest particularly poor in species (Gajardo 1994).

In contrast, the communities of Cuesta Los Cristales (CC) in the Coquimbo Region, and Potrero Grande (PG), El Colorado (EC) and Cuesta Batuco (Bt) in the Maule Region presented the highest values of alpha diversity. All these communities, with the exception of Bt, are surrounded by native forest and situated in the foothills of the Andes cordillera (*i.e.* pre-cordilleran sites), where the effect of land-use changes is still smaller than those reported for the Central Valley or the Coastal Range (Squeo *et al.* 2012, Squeo *et al.* 2010). In the case of CC, the high diversity and composition distinctness (see Fig. 2) is also due to the presence of *Flourensia thurifera* and *Porlieria chilensis*, species that are characteristic of the Atacama Desert flora (Gajardo 1994).

The other variables that according to the regression models contributed significantly to explain the diversity and composition of the studied communities were latitude in the case of the Shannon-Wiener index, altitude in the case of the first axis of the PCoA and latitude and annual mean temperature in the case of the second axis of the PCoA. Besides, the decrease of Shannon-Wiener index with increased latitude could be explained by the higher anthropogenic pressure on natural communities towards the south caused by land use change from native forest to commercial forest (Squeo *et al.* 2010, 2012).

The effect of altitude and latitude on the pattern of similarity in the composition of the communities (given the correlations with the first and second axis of the PCoA) probably results from the fact that contiguous sites tend to share more species than distant sites. For example, as previously mentioned, in the sites located to the southermost of the study area we found species of genera like *Nothofagus*, *Lomatia* or *Austrocedrus*, which are characteristic of the mesophilous forest (Hechenleitner *et al*. 2005), while to the north of the study area we found species that belong to the Atacama Desert flora, like *Flourensia thurifera* and *Porlieria chilensis*. The effect of annual mean temperature is probably because this climatic variable imposes a physiological limit to distributional patterns of species and therefore sites with similar temperature have a more similar floristic composition than sites with different temperatures.

The patterns detected for the phylogenetic diversity metrics in the communities indicated two clear trends. Firstly, there was a decrease in phylogenetic diversity of the communities (indicated by a decrease in Mean Phylogenetic Distance) and an increase in phylogenetic clustering (indicated by a change from negative to positive values in Nearest Taxon Index) with increasing altitude. Secondly, there was also a pattern of south to north decrease in phylogenetic diversity (indicated by a decrease in Mean Nearest Taxon Phylogenetic Distance) and an increase in phylogenetic clustering (indicated by a change from negative to positive values in the Net Related Index). Similar patterns have been found in other regions of the world for insect communities (Hoiss *et al.* 2012; Machac *et al.* 2011) and angiosperm trees (Qian *et al*. 2013) and can be explained by an increase in environmental filtering effects towards higher altitude sites (perhaps because of lower temperatures) and more northern locations (in our case, possibly due to increased aridity). However, an effect of anthropogenic disturbance is also possible, since the presence of adventitious (*e.g*. *Pinus radiata*) species may result in a higher phylogenetic evenness within communities. The abundance of such species was higher at sites surrounded by agricultural or commercial forestry matrices and these sites predominated at lower altitudes and at the southern portion of the studied region.

The highest MPD values were obtained in localities near the native forest or forestry plantation matrix. The values from the forestry plantation matrix are explained by the introduction of exotic plant species to the native communities (Bennett *et al*. 2014), for example *P. radiata.* In addition, the native forest matrix has a high stability of the community due the presence of native flora (Cadotte *et al*. 2012).

CONCLUSIONS

This work provides an update of the diversity and composition of Chilean sclerophyllous forest communities containing *Quillaja saponaria*. We have also evaluated how this diversity and composition changed with variations in the vegetation matrix surrounding these plant communities. It was found that the alpha diversity index of the communities studied was affected by the matrix surrounding the community, with native forest as adjacent matrix being associated with the greatest diversity and number of species in the communities. The results show that studies in greater depth are needed to assess the effects of changes in land use on sclerophyllous forest plant communities, particularly those formed by *Q. saponaria*. There is also a need to study the plant species of the herbaceous stratum, and to associate them with the analyses already carried out, so as to demonstrate whether a greater effect of human activity is found when these elements are incorporated into the analysis.

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