

Riparian or phreatophile woodland and shrubland vegetation in the Central Chilean biogeographic region: phytosociological study

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Abstract. The Mediterranean territory in Chile is an extensive area whose natural vegetation has suffered the impact of man-made activities far more severely than anywhere else in the country. Its northernmost section (the Atacama and Coquimbo regions) is characterised by ombroclimates that range from ultra-hyperarid to arid, and by highly irregular river courses with limited spaces for phreatophilic vegetation that have been exploited by humans as fertile farmlands. However, in the river valleys of the Central Chilean biogeographic province, where the ombroclimate is at least semiarid, there may be permanent watercourses that drain from the Andean mountain range towards the Pacific Ocean that contain representations of riparian or phreatophilic vegetation linked to riverbanks or alluvial terraces, in spite of the inevitable human influence. We studied the most conspicuous plant communities with the most highly developed biomass in these riparian environments, namely willow stands dominated by *Salix humboldtiana* and accompanied by some autochthonous woody species, in order to clarify their floristic composition and their correct ordination within the syntaxonomy of Chilean vegetation. The data collected suggest the existence of a phytosociological association: *Otholobio glandulosi-Salicetum humboldtiana* ass. nova, as the majority association in the Central Chilean province. Another possible association which replaces this (*Baccharido salicifoliae-Myrceugenietum lanceolatae* prov.) is also proposed in the transition to a humid ombroclimate and Temperate macrobioclimate.

The floristic contents of these Chilean communities are compared with other associations dominated by *Salix humboldtiana* described for other territories bordering Chile: Argentina, Bolivia and Peru. However, given that they are all located in a Tropical macrobioclimate and their companion flora is therefore clearly different from the flora present in the Chilean communities, we propose the creation of a new phytosociological class to include these syntaxonomically: *Mayteno boariae-Salicetea humboldtiana* class. nova. This work also ascribes the association *Tessario absinthioidis-Baccharidetum marginalis* (representing a prior dynamic stage to *Otholobio glandulosi-Salicetum humboldtiana*) to the class *Tessario integrifoliae-Baccharidetea salicifoliae*.

Keywords: *Baccharis salicifolia*; Mediterranean rivers; *Salix humboldtiana*; Syntaxonomy; Willow woodlands.

Los bosques y comunidades arbustivas freatófilos riparios en la Región biogeográfica Central Chilena: un estudio fitosociológico

Resumen. El territorio mediterráneo de Chile constituye una amplia superficie cuya vegetación natural ha sufrido el impacto antrópico como ninguna otra en el resto del país. Su tramo más septentrional (regiones de Atacama y Coquimbo) caracterizada por ombroclimas de ultrahiperárido a árido presenta unos cursos fluviales muy irregulares y los reducidos espacios para vegetación freatófila han sido aprovechados por el hombre como fértiles terrenos de cultivo. Pero en los valles fluviales de la provincia biogeográfica Chilena Central, cuando el ombroclima es al menos semiárido, ya se pueden presentar cursos de agua permanente que drenan desde la cordillera andina hacia el Pacífico y en los que se pueden encontrar representaciones de la vegetación riparia o freatófila ligada a márgenes fluviales o terrazas aluviales, a pesar de la inevitable influencia humana. Se estudiaron las comunidades vegetales más desarrolladas en biomasa y más conspicuas de estos ambientes riparios, que son las saucedas dominadas por *Salix humboldtiana* al que acompañan algunas especies leñosas autóctonas. Los datos recopilados sugieren la existencia de una asociación fitosociológica: *Otholobio glandulosi-Salicetum humboldtiana* ass. nova, mayoritaria en la provincia Chilena Central, más otra posible asociación (*Baccharido salicifoliae-Myrceugenietum lanceolatae* prov.) que sustituye a la anterior entrando en ombroclima húmedo y bioclima Templado.

Se comparan los contenidos florísticos de estas comunidades chilenas con otras asociaciones dominadas por *Salix humboldtiana* que se han descrito de otros territorios vecinos a Chile: Argentina, Bolivia y Perú. Pero dado que todos ellos se sitúan bajo bioclima Tropical y por ello su flora acompañante es claramente diferente a las comunidades chilenas, se propone la creación de una nueva clase fitosociológica para encajar a éstas sintaxonómicamente: *Mayteno boariae-Salicetea humboldtiana* classis nova. Asimismo, en este trabajo se adscribe la asociación *Tessario absinthioidis-Baccharidetum marginalis* (que representaría una etapa dinámica previa a *Otholobio glandulosi-Salicetum humboldtiana*) a la clase *Tessario integrifoliae-Baccharidetea salicifoliae*.

Palabras clave: *Baccharis salicifolia*; Ríos mediterráneos; *Salix humboldtiana*; Saucedas riparias; Sintaxonomía.

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Introduction

The potential natural vegetation of Chile is reasonably well known, and has been disseminated via several successful mapping approaches (Gajardo, 1994; Luebert & Plissock, 2006a, 2017; Amigo *et al.*, 2017). One of the mostly widely accepted opinions among authors is the high degree of anthropisation and degradation of the natural vegetation in the territory in Central Chile, coinciding with the regions of greatest population density or the highest agricultural yields. The adjoining regions of Valparaíso, Metropolitana, O'Higgins and Maule all share these characteristics and the natural ecosystems in these places are all in clear regression. With the possible exception of high-mountain formations (high-Andean scrublands, hygrophilous pastures or chionophilous communities), the sclerophilous or deciduous woodland formations characteristic of the Mediterranean climate can be signalled as being the most endangered, despite the fact that this Central Chilean area lies within a major biodiversity hotspot (Arroyo *et al.* 2004). It should be noted that there have been different opinions regarding the concept of Mediterranean climate (Blumler, 2005) which have led as a result to the consideration of a larger or smaller territorial area in Chile depending on the case; this diversity of criteria for the Chilean Mediterranean is concisely described in Luebert & Plissock (2006b), who ultimately accept the map delimitation contained in the models of Rivas-Martínez (2004) as being the most appropriate, for which there is a somewhat more updated version in Rivas-Martínez *et al.* (2011a). We have used this most recent version as a reference for the present work, although these authors differ slightly (Luebert & Plissock, *op. cit.*; Rivas-Martínez *et al.*, *op.cit.*) in their definition of the southernmost limit of the Mediterranean Macrobioclimate.

Riparian woodlands must be included in the woodland types that form part of the group known as “Chilean Mediterranean woodlands with a very reduced extension”. The spaces previously covered by these woodlands have suffered massive deforestation and exploitation throughout the whole of Mediterranean Chile, and this phenomenon is even more pronounced in drier climates, as the river valleys are the main –and almost always the only– option for producing the crops required for any human settlement. The part that is climatically least affected by drought, which we identify with the Mediterranean pluviseasonal bioclimate (*sensu* Rivas-Martínez *et al.*, *op. cit.*), is home to a woodland type presided by laurisclerophilous mesophanerophytes characteristic of streams and tributaries within the thermomediterranean thermotype that do not –or only scarcely– dry out. This woodland receives the name *Beilschmiedio miersi-Crinodendretum pataguae*, and has tall trees with microphanerophytes, creepers and diverse herbaceous plants in its understorey, and a notable set of associated species which connects it with the alliance *Cryptocaryion albae* (*Lithraeo causticae-Cryptocaryetea albae*). Amigo & Flores-Toro (2012) described some samples of its floristic composition (average richness 25 species/relevé) although it had

previously been assessed as a community of significant rarity.

However, there are other types of autochthonous riparian tree and shrub formations that have attracted very little interest from geobotanists in Chile for reasons that will be described below, but which play a crucial role in protecting the riverbanks and the fertility of the sediments that they help to retain. Oberdorfer (1960) was the first to call attention to them, when he found scrubland formations on the floodplains of major rivers on banks with accumulations of gravel, or gravel and sand, sometimes extending for several kilometres along the length of the riverbank. Although he collected scarcely four relevés in these scrublands, he noted their ecological position, which he assessed as a vicariant of the European scrublands classified within the class *Salicetea purpureae*; continuing this parallelism he assigned a provisional association name to this single table of four relevés: *Tessario absinthioidis-Baccharidetum marginalis*, and proposed their syntaxonomical affiliation to a possible *Salicetea chilena* (*sic*), also as a provisional name. Although the association was defined as a community of shrubs measuring barely 1–2 m in height, he acknowledged the participation of other taller woody species such as *Othobium glandulosum* and *Salix humboldtiana*. It is also worth noting that the companion species in this table of relevés included exotic tree species whose role as invasive elements in the riverbeds of the Chilean Mediterranean rivers has continued to grow to the point that in many sections they have displaced this natural vegetation. To maintain Oberdorfer's original reasoning (*op. cit.*), we will continue to call this natural vegetation “*Salicetea chilena*” until we propose a valid name according to the International Code of Phytosociological Nomenclature (Weber *et al.*, 2000; Izco & Del Arco, 2003), which will be addressed in the Discussion section.

We have explored and sampled a large part of the Mediterranean territory in search of well conserved examples of these willow/shrub formations, avoiding wherever possible the riverbanks invaded by exotic trees, which is the first risk factor for this type of vegetation as a result of the pressure from anthropisation. The communities they form in Chile are apparently quite well defined, but the task of placing them within a syntaxonomical hierarchy is more complex given the wide territorial range of some of their characteristic species in South America.

Study area

The territory covered extends through the centre of Chile from the south of the Coquimbo region to the south of the Bio-Bio region, between latitudes 31° 44' and 37° 49' S; throughout this territory the studied samples were always located at low altitudes with extreme values of between 25 m and 820 m asl. The dispersion of the sampling can be seen in Figure 1, which shows the absence of specimens in non-Andean areas between latitudes 33° and 36° south, as these

are areas that are intensively used for agriculture and where the river networks have undergone a very serious degree of anthropisation. Biogeographically it is part of the Middle-Chilean Patagonian region and the Central Chilean province, following the classification of Rivas-Martínez *et al.* (2011b), which is the model we will use for all the biogeographic units mentioned in this work (see later on Figure 5). The northernmost samples are located at the limits with the desertic Mediterranean Chilean province which begins in the Choapa River

valley and extends northwards; from this point the ombroclimate becomes generally more arid, in contrast to the semiarid character of the territory to the south of the river. At the southernmost limits of the sampling, in the Ñuble and Bio-Bio regions, some samples were taken on riverbanks at points located within the Valdivian-Magallanic biogeographical region, given that a little further to the south of parallel 36° the Chilean flank of the Andes, up to certain levels of its foothills, lies within the Temperate macrobioclimate.

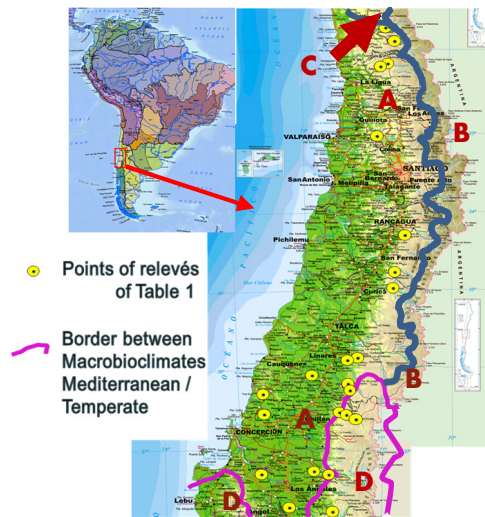


Figure 1. Administrative map of Central Chilean territory showing geographical dispersion of river points where samples gathered in Table 1 were taken. The thick lines delimit the biogeographical provinces according to Rivas-Martínez *et al.* (2011b): A) Central Chilean. B) Mediterranean Andean. C) Desertic Mediterranean Chilean. D) Valdivian.



Figure 2. Substrate heterogeneity on the riverbanks: always sand, but also gravels and rocks. Rio Claro, Tinguiririca tributary, O'Higgins region (34° 44' S). Subhumid mesomediterranean thermotype.



Figure 3. Typical landscape of a river in a broad valley with riverbank vegetation linked to smaller streams prone to dry out; the willow stand can be seen to be separate from the other phreatophilic scrublands. River Cachapoal, O'Higgins region (34° 22' S). Dry mesomediterranean thermotype.



Figure 4. Dense willow stand of *Salix humboldtiana* in a narrow valley. The abundance of the allochthonous herb *Galega officinalis* is significant. Rio Claro, Pangal tributary, O'Higgins region (34° 16' S). Dry mesomediterranean thermotype.

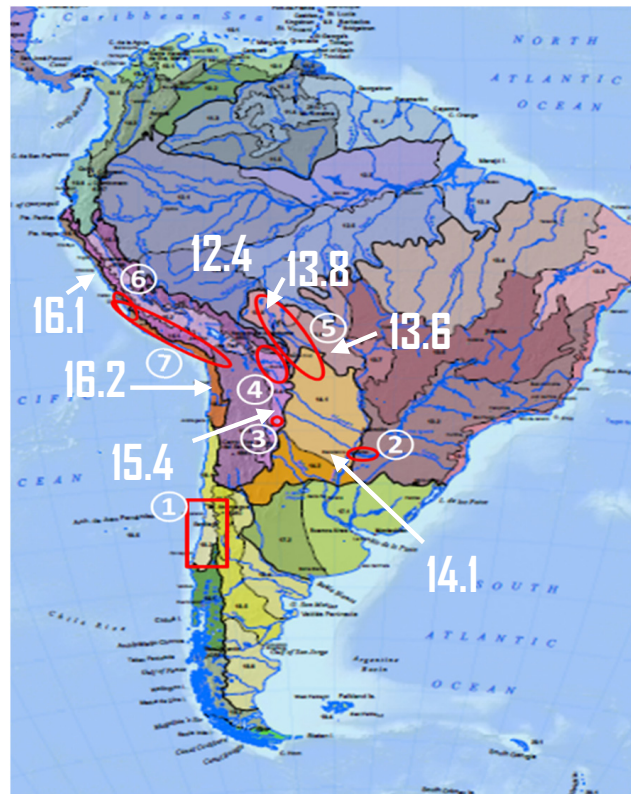


Figure 5. Biogeographical map of South America *sensu* Rivas-Martínez *et al.* (2011b). The rectangle indicates the Central Chilean province and the ellipses denote the tropical areas that contain the willow communities shown in Table 3. Biogeographical provinces concerned (numeric codes are the same as in the map from Rivas-Martínez *et al.* (*op.cit.*): 12.4: Southwest Amazonian; 13.6: West Cerrado; 13.8: Benian; 14.1: North Chacoan; 15.4: Bolivian-Tucumanean; 16.2: Hyperdesertic North Peruvian; 16.2: Hyperdesertic Tropical Chilean-Arequipán.

Riverbanks were sought throughout this entire territory with autochthonous willow/shrub formations located in rivers with a very variable flow: from small, with a width of barely 6 m between their banks (Estero Pupío, rel. 3, Table 1), to very large (400 m in the Itata River, rel. 20, Table 1). We visited the most important rivers in this territory, whose main reach or some of whose tributaries flow into the Pacific, and collected samples; the following rivers are thus represented: Choapa (with its tributaries Zapallar and Limahuida), Petorca (with Pederal), Aconcagua, Maipo, Rapel (with Pangal and Tinguiririca), Mataquito (with Teno and Lontué), Maule (with Longaví), Itata (with Ñuble) and Bio-Bio (with Laja, Queuco and Bureo).

Bioclimatically most of the localities can be assigned to the mesomediterranean thermotype, although the thermicity levels of all the sites in the Coquimbo region justify their attribution to the thermomediterranean thermotype, in common with some sites in the north of the Valparaíso region. However, as mentioned above, some southern localities can be assigned to the mesotemperate thermotype. There is an acceptable number of Mediterranean meteorological stations listed in Amigo & Flores-Toro (2017), in addition to the global data for all Chile in Luebert & Plissock (2006b, 2017). The ombroclimate covers the whole upward precipitation gradient known throughout this Central Chilean province: from the Choapa valley to the capital Santiago, almost all the stations have a semiarid character with some exceptions nearer the coast. Between parallels 33° and 34°S there is a predominantly dry ombroclimate,

and an absolute prevalence of the subhumid to the south of this latitude. This refers to altitudinal levels of less than 1000 m asl, which is where most of the human population is located (and the meteorological recording stations); in this case it also coincides with the preferences of “*Salicetea chilena*” formations, as no examples of willow stands were found above this limit. The relevés belonging to localities with a Temperate macrobioclimate can probably, without exception, be assigned to a humid ombroclimate.

Species such as *Salix humboldtiana* are known to have a very broad distribution, not only towards northern Chile, but also throughout tropical South America as far as Mexico, and in Chile itself it is known from Arica to Malleco in Araucanía (San Martín & Véliz 2006). However, in the arid ombroclimate (that is, also including hyper-arid and ultra-hyper-arid values) that covers all Chilean regions from the Peruvian border to the southern Coquimbo region, the anthropisation of the river courses is extremely intense, and the presence of these tree formations with varying degrees of naturalness can be said to be incidental. We therefore did not attempt to cover this vast territory due to the scant results to be yielded from our efforts. Nor did we work in the Araucanía region as the Mediterranean/temperate limit prevails in the northern section of this region even at the level of the Central Depression. Northern Araucanía also marks the absolute limit of the southern distribution of *Salix humboldtiana* in Chile (Hauenstein *et al.*, 2005) so the presence of autochthonous willow formations at these latitudes can be assumed to be scarce and of little interest.

Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
<i>Juncus dombevanus</i>	+	.	.	.	.	.	.	.	2	1	.	.	2	.	1	2	+	.	.	.	1	.	.	.	.	.	r
<i>Verbena litoralis</i>	+	.	1	.	.	.	+	1	.	.	.	+	.	.	1	+	+	.	.	.	.	.	.	.	.	.	.
<i>Cortaderia gr. selloana</i>	+	.	.	1	.	.	.	.	.	.	.	1	.	.	1	.	.	+	.	.	1	.	1	.	.	.	+
<i>Hydrocotyle cf. chamaemorus</i>	2	.	.	.	.	r	1	.	.	1	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.
<i>Isolepis cernua</i>	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+
Companion species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Rubus ulmifolius</i> (x)	.	+	.	.	.	.	.	.	.	.	2	+	1	+	1	2	+	4	+	.	.	.	1	2	2	.	.
<i>Lotus uliginosus</i> (x)	.	.	.	.	.	.	.	.	1	.	2	1	+	+	1	1	.	1	.	.	1	1	1	+	.	.	1
<i>Galega officinalis</i> (x)	.	.	.	2	.	.	.	4	4	5	5	+	+	1	.	2	1	4	.	.	.	1	+	.	.	.	.
<i>Cyperus eragrostis</i>	.	.	.	.	.	.	.	1	+	+	.	.	.	1	1	1	1	+	1	.	1	1	.	.	.	.	+
<i>Veronica becabunga</i> (x)	+	.	.	+	+	.	.	.	.	1	1	+	1	1	.	.	+	.	.	.	.	.	.	.	.	.	.
<i>Baccharis linearis</i>	+	.	.	.	.	+	+	.	.	.	.	+	.	.	.	.	.	+	.	.	+	.	.	.	.	.	+
<i>Schinus polygamus parviflorus</i>	+	.	.	.	.	+	3	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
<i>Agrostis capillaris</i> (x)	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	1	.	2	.	.	.	.	.	.	.	.	.
<i>Mentha pulegium</i> (x)	.	.	.	.	.	.	+	.	.	.	.	.	1	.	.	.	2	1	.	.	.	.	.	+	.	.	.
<i>Dysphania ambrosioides</i>	.	.	.	.	.	.	+	.	.	.	.	.	.	r	+	.	+	.	.	.	r	.	.	.	.	.	.
<i>Prunella vulgaris</i> (x)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	+	.	.	+	.	.	+	1	.	.
<i>Muehlenbeckia hastulata</i>	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
<i>Rosa rubiginosa</i> (x)	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	1	+	+
<i>Cissus striata</i>	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.
<i>Mentha aquatica+piperita</i> (x)	1	.	.	.	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Saponaria officinalis</i> (x)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	+
<i>Balbisia gracilis</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1
<i>Cestrum parqui</i>	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Sophora macrocarpa</i>	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
<i>Typha domingensis</i>	.	.	+	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Melilotus alba</i> (x)	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
<i>Eleocharis macrostachya</i>	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.
<i>Schoenoplectus pungens</i>	.	.	.	1	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Paspalum distichum</i>	.	.	.	.	.	.	.	.	3	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
<i>Anagallis alterniflora</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.
<i>Discaria chacaye</i>	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.	.
<i>Lithraea caustica</i>	.	r	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	+	.	.	.

Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
<i>Xanthium strumarium</i> (x)	1	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.
<i>Polygonum hydropiperoides</i>	1	.	.	.	.	1	.	r	.	.	.	.	.	.	.	.	.	.
<i>Hypericum perforatum</i> (x)	1	1	.	.	+	.	.	.	.	.	.	.	.
<i>Juncus effusus</i>	2	.	.	+	.	.	.	.	.	.	.	.	.	.	.
<i>Plantago lanceolata</i> (x)	+	.	.	.	1	.	.	.	.	.	.	1
<i>Holcus lanatus</i> (x)	+

Other species: *Baccharido-Myrcenigenetum*: *Fuchsia magellanica* + in 23, 26; *Azara celastrina* 2 in 24, 3 in 25; *Libertia chilensis* 1 in 24, 2 in 25; *Buddleja globosa* 1 en 23; *Colliguaja dombeyana* 1, *Escallonia rubra* var. *macrantha* 2 in 24; *Podocarpus saligna* 1 in 25. Companion species: *Apium nodiflorum* 1 in 2, + in 3; *Schinus molle* + in 2, 2 in 3; *Mimulus luteus* r in 5, 1 in 7; *Anthemis cotula* 1 in 6, 7; *Ludwigia pepioides* 1 in 9 and 14; *Cyperus reflexus* + in 16, 17; *Nothofagus dombeyi* + in 21, 1 in 22; *Chusquea cumingii* 2 in 24, 3 in 25; *Blechnum hastata* + in 24, 1 in 25; *Lardizabala bitemata* 1 in 24, 25; *Galium hypocarpium* +, *Carex excelsa*, *Eucalyptus* sp. 1 in 1; *Solanum pinnatum* +, *Valeriana bracteosa* 1 in 3; *Tristerix tetrandrus* + in 5; *Phylla nodiflora* + in 7; *Proustia pyrifolia* and *Vinca major* + in 8; *Calystegia septium*, *Schoenoplectus californicus*, *Alisma plantago-aquatica* 1, *Salix purpurea* 2, in 9; *Baccharis sagittalis* r, *Mimulus glabratus* + in 11; *Lythrum hyssopifolia* +, *Cyperus aristatus* var. *inflexus* 1, *Salix aff. fragilis* 2 in 14; *Eryngium paniculatum* + in 15; *Isolepis nigricans* +, *Carex excelsa*, *Festuca arundinacea* 1 in 16; *Eragrostis curvula* + in 18; *Juncus balticus* + in 19; *Koivippa* sp., *Calystegia septium* + in 20; *Nothofagus obliqua* (p1) r, *Baccharis gr. obovata* +, *Symphoricarpon vahlii* 1 in 21; *Drimys winteri*, *Crinodendron patagium*, *Trifolium repens*, *Sporobolus indica*, *Leontodon taraxacoides* and *Paspalum dilatatum* 1 in 22; *Cryptocarya alba*, *Aldama revoluta*, *Ribes punctatum*, *Blechnum chilense* and *Proustia pungens* + in 23; *Anomyrtus luma* + in 24; *Lardizabala bitemata*, *Cryptocarya alba* 2, *Luma apiculata* 1, *Aextoxicon punctatum*, *Bomarea crassicaulis*, *Leptocarpha rivularis*, *Sanicula crassicaulis*, *Valeriana crispa* + in 25; *Aldama revoluta* r, *Baccharis aff. paniculata* 1 in 26. Localities: Province, Comuna, Administrative Regions: 1–5, Coquimbo; 6–7, Valparaíso; 8, Metropolitana; 10–11 O'Higgins; 12–13, 22–25, Maule; 14, 15, 20, 21, 26, Ñuble; 9, 16–19, Bio-Bio. 1: Choapa, Salamanca; from Cunlagua to S Agustín, Zapallar river (31° 44' 02" / 70° 53' 16"); 2: Choapa, Los Vilos; road to Caimanes, Púpio Estero (31° 51' 53" / 71° 20' 18"); 4: Choapa, Salamanca; Coirón, Choapa river (31° 53' 52" / 70° 46' 19"); 5: Choapa, Los Vilos; between Caimanes and Mauro, Púpio Estero (31° 56' 59" / 71° 04' 14"); 6, 7: Putorca, Putorca; from Chalaco to Pedernal, Pedernal river (32° 08' 17" / 70° 47' 58"); 8: Chacabuco, Til-Til; road bifurcation Til-Til/Caleu, Til-Til estero (33° 01' 13" / 70° 55' 05"); 9: Bio-Bio, Mulchén; at the entrance of Mulchén, Claro river, tributary of Tinguiririca river (34° 44' 39" / 70° 46' 09"); 10: Cachapoal, Requinoa; between Gultro and Coya, bridge over Claro river, tributary of Pangal river (34° 16' 21" / 70° 35' 10"); 11: Colchagua, San Fernando; from El Llano to Sierra Bella Vista, Claro river, tributary of Tinguiririca river (36° 25' 39" / 72° 39' 49"); 12: Curicó, Romeral; bridge at the East of Los Quehes, Teno river (34° 59' 59" / 70° 47' 32"); 13: Linares, Parral; road to Cauquenes, no-name river, tributary of Perquillauquén (36° 05' 42" / 71° 55' 28"); 14: Ñuble, Trehuaco; at the entrance of Trehuaco, Lonquén river (36° 25' 39" / 72° 13' 47"); 15: Ñuble, San Fabián; San Fabián bridge, Ñuble river (36° 33' 42" / 71° 33' 52"); 16: Bio-Bio, Quilleco; from Antuco to Quilleco, Rucúe river (37° 20' 36" / 71° 47' 46"); 17: Bio-Bio, Tucapel; at the entrance of Tucapel, Laja river (37° 18' 04" / 71° 58' 05"); 18: Bio-Bio, Mulchén; Bio-Bio river, west of Ralco, downstream of the Queuco river junction (37° 49' 17" / 71° 40' 46"); 19: Concepción, La Laja; at the entrance of La Laja, Bio-Bio river (37° 18' 06" / 72° 42' 38"); 20: Ñuble, Quillón; Nipas bridge on the north bank of Itata river (36° 35' 44" / 72° 32' 28"); 21: Ñuble, San Fabián; Los Puquitos, at the East of San Fabián, Ñuble river (36° 38' 21" / 71° 24' 36"); 22: Linares, Linares; at the South of Roblería, Ancoa river (35° 54' 14" / 71° 17' 12"); 23: Linares, Linares; close to Chupallar, Ancoa river (35° 51' 31" / 71° 12' 54"); 24: Linares, Parral; road to Bullileo dam, no-name left side tributary of Longavi river (36° 14' 27" / 71° 26' 25"); 25: Linares, Parral; at Bullileo village, Bullileo river (36° 16' 22" / 71° 24' 58"); 26: Ñuble, San Fabián; Los Puquitos, at the East of San Fabián, Ñuble river (36° 38' 23" / 71° 24' 34").

Materials and Methodology

Numerous expeditions were made in search of river courses whose banks fulfilled the topographic conditions that favour the deposit of materials dragged from the headwaters of these rivers; the ecology of *Salix humboldtiana* prevents it from colonising rocky riverbanks formed exclusively of boulders, as it requires at least minimal deposits of fine materials (sand or silt) to become established. In all cases we sought out river shrubland formations dominated by autochthonous species with or without the presence of *Salix humboldtiana*, as the communities of “*Salicetea chilena*” tend to disappear when rivers flow near anthropised areas (farmlands, dammed river reaches, etc.) due to the destruction of their habitat or to massive invasions of allochthonous trees.

A set of 35 relevés were taken in all the selected localities following the syngamist phytosociological method (Braun-Blanquet, 1979 updated by Dierschke, 1994). Two tables were built grouping both sets of relevés by floristic affinities, in order to profile communities that reflected our judgement of what may represent the class “*Salicetea chilena*” proposed by Oberdorfer (1960) in Chile.

We follow Zuloaga *et al.* (2009) and Rodríguez *et al.* (2018) as a taxonomic reference for all the vascular flora; however we make an exception in the case of the composite *Baccharis confertifolia* Bert. ex Colla, a taxon assumed by both references to be merely a synonym of *Baccharis salicifolia* (Ruiz & Pav.) Pers. *B. confertifolia* was recognised in the past as an independent species in the Flora of Chile (Marticorena & Quezada, 1985), and even this century in the print version of the Flora of the Southern Cone (Zuloaga *et al.*, 2008). We are unaware of any possible subsequent taxonomic studies, but in the most recent update of the genus by Giuliano & Plos (2014), it was assumed to be synonymous within the concept of *B. salicifolia*. However in our study of these communities we have confirmed a phenotype that we identify with *B. confertifolia*, and that can be clearly distinguished by its more linear –sometimes practically acicular– leaves, which give the shrub an appearance that is more similar to the branches of a young pine than the lanceolate leaves presented by the typical *Baccharis salicifolia*. This clear morphological differentiation, coupled with the geographic distinction we also observed and which will be discussed in the Results section, lead us to defend the independence of the taxon *Baccharis confertifolia* Bert. ex Colla.

For syntaxonomical purposes, we followed the guidelines in the third edition of the International Code of Phytosociological Nomenclature (Weber *et al.*, 2000; Izco & Del Arco, 2003).

Results

The formations containing a predominance of *Salix humboldtiana* (“Humboldt’s willow”) can be interpreted as a clearly recognisable association throughout

almost the entire territory in the study, whose floristic composition is shown in Table 1. We assign it the name of *Otholobio glandulosi-Salicetum humboldtiana* ass. nova hoc loco, (*holotypus* rel. 11). These are tree/shrub formations (micro-woodlands *sensu* Rivas-Martínez 2004), since the autochthonous willow barely exceeds 10–12 m in height; this does not prevent other taller exotic trees from occasionally appearing, either on a second front of phreatophilic tree formations or else completely mixed with *Salix humboldtiana*. The species most frequently encountered include *Populus nigra* and *P. xcanadensis* (described in Table 1 as a “collective” taxon), *Salix babylonica* and *Acacia dealbata*.

The geomorphological features of the riverbanks where these willow stands become established are quite varied, as *S. humboldtiana* can tolerate very precarious conditions in terms of soil formation. Its pioneering character is probably its greatest adaptive quality, so it can be found growing on banks with a predominance of gravel and particularly sand, and even in torrential river reaches with an abundance of boulders; its broad ecological range means it is also present on completely silted banks with well-formed soil with fine sediment, although it has usually been displaced from these types of sites with more fertile soils due to their use by humans as farmlands or pastures. Table 1 includes, for each relevé, a descriptive code of the gravimetric composition of the substrate according to size: rock, gravel, sand or silt (Figure 2). Many of the main rivers in the Central Chilean province have a very broad secondary riverbed as they flow through the Central Depression on their way to the Pacific, in which large extensions of gravel or sand have accumulated intermittently along their length and breadth. Thus except in major flooding events, the river’s normal regime consists of a main flow of water, and lateral streams with shallow or stagnant water or which are in the process of drying up; these irregular streams are prone to colonisation by the Humboldt’s willow, which is therefore sometimes found at some distance from running water (Figure 3). As a result of this diversity of substrates in the sites where these willow stands become established, the main companion species are similarly versatile woody plants such as *Otholobium glandulosum* and *Baccharis salicifolia*, the second of which is substituted in northerly relevés by *B. confertifolia*, a phenomenon already noted by Oberdorfer (1960) in his description of *Tessario-Baccharidetum marginalis*. Other hygrophilous shrubs, although with a lesser presence, are *Luma chequen*, *Tessaria absinthioides* and *Discaria trinervis*. *Maytenus boaria* and *Aristotelia chilensis* have a higher frequency because both present a broad distribution in the Mediterranean and humid temperate territory, and both are perfectly integrated in the riparian shrublands that replace these Humboldt’s willow stands towards the river headwaters, with steeply sloping banks and narrow channels and a predominance of boulders, also extending into the supramediterranean thermotype. These are the habitat characteristics of the communities that were described and grouped into an alliance *Escallonion illinito-myrtoidae*, proposed as provisional by Amigo & Flores-Toro (2017) with

two associations that can be integrated in the concept of “*Salicetea chilena*”; we have therefore selected *Maytenus boaria* and *Aristotelia chilensis* as territorial characteristics of this possible class.

One notable feature of the floristic composition of *Otholobio glandulosi-Salicetum humboldtiana* is the inevitable presence of both herbaceous and woody allochthonous species, most of which have the clear denomination of invasive exotic species. They have been labelled with a specific symbology in Table 1 (in addition to the aforementioned woody species) to highlight the fact that this ecological environment continues to suffer particularly aggressively from human activities. The frequent incursions of *Galega officinalis* in this environment is a clear example of this (Figure 4).

Two significant trends can be noted with regard to the variability of this association. One floristic peculiarity of all the northernmost relevés located between the south of Coquimbo and towards the north of the Metropolitana region, with a semi-arid ombroclimate, is the participation of *Baccharis confertifolia* and often also *Escallonia illinita* and *Equisetum giganteum* [although according to Rodríguez *et al.* (2018) this corresponds to *Equisetum pyramidale* Goldmann, as these authors defend the independence of this taxon from *E. giganteum* L.]. Relevés 1–8 in Table 1 are only differentiated as a variant of *Baccharis confertifolia*, whose biogeographical and ecological significance is interpreted as being linked to the character of semi-arid ombroclimate.

There is a further group of relevés that mark another biogeographical differentiation: the presence of an additional hygrophilous shrubland can be seen towards the southern section of the territory in the study (south of Maule, Ñuble and Bío-Bío), which could be presented as dominant, although its height never exceeds that of Humboldt’s willow: *Myrceugenia lanceolata*. We considered it particularly interesting to find formations of riparian shrublands with a dominance of this Myrtaceae species in relevés from more torrential reaches of rivers with headwaters within the Temperate macrobioclimate; as mentioned earlier, some of these relevés may even fall within this bioclimatic territory. It is our opinion that with more information it will be possible to confirm this community as a different association, for which we propose a provisional name: *Baccharido salicifoliae-Myrceugenietum lanceolatae*. We have only assigned it relevés 23–26 in Table 1 due to the absence of *Salix humboldtiana*, although obviously there are some transitional situations in which *Salix humboldtiana* and *Myrceugenia lanceolata* (rels. 21 and 22) coexist. Some species that may be significant in differentiating this other association are *Sophora cassioides*, *Azara celastrina*, *Buddleja globosa* or *Colliguaja dombeyana*; the presence of *Rosa rubiginosa* is only due to the type of substrate with a predominance of coarse materials (rocks and gravels) frequently found on riverbanks with this community.

In our search for riverbanks with shrub formations containing willows, we found a range of situations with a floristically impoverished version of the *Otholobio*

glandulosi-Salicetum humboldtiana in more open formations with not very dense cover and where, apart from the inevitable xenophytes, there are no more than half a dozen autochthonous species that are typical of the hygrophilous environment. These situations are physiognomically defined as phreatophilic scrublands (as they are less than 2–3 m in height, and their root stratum is not always in contact with flowing water) and are more similar to the community designated by Oberdorfer (*op. cit.*) as *Tessario-Baccharidetum marginalis*; we show a sample of this community in Table 2. Although most of the species in this community in Table 2 are also integrated in the relevés in Table 1, the dynamic relation between both has led us to consider them separately, as described in the following section.

Discussion

From the data provided so far we can argue in favour of recognising an association *Otholobio glandulosi-Salicetum humboldtiana*, widely distributed throughout the thermo- and mesomediterranean thermotypes in ombroclimates ranging from semiarid (at its limit with the arid) to the humid ombroclimate in the Central Chilean province. Once in the humid ombroclimate and penetrating slightly into the territory of the Temperate macrobioclimate there is a riparian community where *Salix humboldtiana* has already failed and the presence of the myrtaceae *Myrceugenia lanceolata* has gained predominance. We consider that this last, which we have called *Baccharido salicifoliae-Myrceugenietum lanceolatae*, represents a transition between the Mediterranean phreatophilic and riparian formations on highly fluctuating flows and the formations that appear when the rivers or streams have a more stable flow and when the ombroclimate becomes more humid. San Martín *et al.* (2001) described an important example of this type of riparian shrublands in the mesomediterranean territory in the Maule region, in which the most notable components are several myrtaceae species; it was assigned the name of *Myrceugenio-Tepualietum stipularis*, which is in fact an invalid name (due to the ambiguity caused by the lack of precision in the species of *Myrceugenia* used for the name, according to art. 3g of the ICPN), but which is a good example of how different “myrtles” (*Tepualia stipularis*, *Myrceugenia pinifolia*, *M. lanceolata*, *Luma apiculata*) colonise the riverbanks along with the typical temperate woodland species (*Nothofagus dombeyi*, *Drimys winteri*, *Podocarpus saligna*, etc.) when the river regime becomes more constant and moves away from the prevailing model in the Mediterranean macrobioclimate. This is a constant phenomenon in the Temperate and pluviseasonal Mediterranean territories in situations of stagnant waters that generate the swampy myrtle woodlands which are designated by the order *Myrceugenietalia exsuccae* (*Palud-Myrceugenietalia sensu* Oberd. 1960) in the class *Wintero-Nothofagetea*.

Table 2. *Tessario absinthioidis-Baccharidetum marginalis* Oberd. 1960

Riverbank composition: R/r = rocks (> 50 cm Ø); G/g = gravel (< 50 cm Ø); S/s = sand; L/l = silt. Capitals indicate abundant, lowercase scarce; (x) = xenophytic plant

Altitude (m asl)	160	225	1110	1055	505	630	80	510	455
Area (m ²)	80	180	100	250	200	100	60	150	90
Slope (°)	0	0	0	10	0	0	5	5	15
Cover E ₁ (%)	100	85	100	60	70	60	70	80	70
High shrub layer (m)	5–8	3–8	1–3	1–2	1–2.5	1–3	1–6	1–5	1–3
Riverbank composition	gsL	gS	rGS	RGS	rGS	rGs	RGs	GSI	RGs
Latitude	34° 03'	34° 22'	35° 02'	35° 02'	35° 42'	36° 53'	36° 51'	37° 49'	37° 53'
N. species	11	10	14	9	13	9	9	10	10
N. relevé	1	2	3	4	5	6	7	8	9
<i>Baccharidetea / Salicetea</i> species									
<i>Baccharis salicifolia</i>	1	3	3	3	4	3	3	4	4
<i>Otholobium glandulosum</i>	2	1	.	.	3	3	.	4	1
<i>Cortaderia gr. selloana</i>	.	r	1	+	1	+	.	.	1
<i>Salix humboldtiana</i>	4	4	.	.	.	.	2	.	.
<i>Tessaria absinthioides</i>	.	3	4	3	+	.	.	.	.
<i>Equisetum bogotense</i>	.	.	2	.	1	.	.	.	.
<i>Discaria trinervis</i>	.	.	3	.	.	1	.	.	.
<i>Buddleja globosa</i>	.	.	+	.	.	.	.	.	.
<i>Escallonia myrtoidea</i>	.	.	+	.	.	.	.	.	.
<i>Myrceugenia lanceolata</i>	.	.	.	.	.	.	1	.	.
<i>Stemodia durantifolia</i> var. <i>chilensis</i>	.	.	.	.	.	.	r	.	.
<i>Rhodoscirpus asper</i>	.	.	.	.	+	.	.	.	.
Native helophytes									
<i>Polygona australis</i>	1	.	.	.	1	.	.	.	.
<i>Eleocharis bonariensis</i>	.	.	.	.	.	.	+	+	.
<i>Cyperus eragrostis</i>	.	.	.	.	.	.	.	+	+
<i>Juncus balticus</i>	.	.	.	.	1	.	.	.	.
<i>Symphyotrichum vahli</i>	.	.	.	.	.	+	.	.	.
<i>Isolepis cernua</i>	.	.	.	.	.	.	.	2	.
Companion species									
<i>Galega officinalis</i> (x)	1	2	3	1	.	.	.	.	3
<i>Rubus ulmifolius</i> (x)	5	.	.	.	.	1	.	.	+
<i>Salix babylonica</i> (x)	2	.	.	.	+	.	.	1	.
<i>Lotus pedunculatus</i> (x)	.	.	+	.	+	+	.	.	.
<i>Acacia dealbata</i> (x)	.	1	.	.	.	+	.	.	.
<i>Populus nigra</i> (x)	.	1	.	.	.	.	2	.	.
<i>Balbisia gracilis</i>	.	.	+	.	+	.	.	.	.
<i>Tetraglochin alatum</i>	.	.	+	.	.	.	.	.	.
<i>Medicago sativa</i> (x)	.	.	+	1	.	.	.	.	.
<i>Melilotus alba</i> (x)	.	.	.	+	2	.	.	.	.
<i>Saponaria officinalis</i> (x)	.	.	.	.	.	2	.	.	+
<i>Agrostis capillaris</i> (x)	.	.	.	.	.	.	.	1	1

Other species: *Maytenus boaria*, *Muehlenbeckia hastulata*, *Typha domingensis* +, *Mentha piperita* 1 in 1; *Rumex obtusifolius* +, *Sisymbrium officinale* 1 in 2; *Medicago lupulina*, *Diostea juncea* + in 3; *Adesmia coronilloides* +, *Baccharis aff. paniculata* 1 in 4; *Cytisus striatus* r in 5; *Paspalum distichum*, *Xanthium strumarium* +, *Alnus glutinosa* 1 in 7; *Hydrocotyle gr. chamaemorus*, *Juncus gr. capitatus* +, *Mentha pulegium* 1 in 8; *Juncus effusus*, *Rosa rubiginosa* + in 9. Localities: Province Comuna; Administrative Regions: 1, Metropolitana; 2–3, O'Higgins; 4–5, Maule; 6–7, Ñuble; 8–9, Bio-Bio. 1: Melipilla, Alhué, at West of Loncha, banks of estero Alhué (34° 03' 42" / 71° 13' 49"); 2: Cachapoal, from Peumo to Doñihue, banks of Idahue river (34° 22' 46" / 71° 08' 58"); 3: Curicó, Romeral; close to Los Cipreses, Teno river (35° 02' 40" / 70° 35' 30"); 4: Curicó, Romeral; at West of Los Cipreses, Teno river (35° 02' 51" / 70° 37' 06"); 5: Talca, San Clemente; Armerillo, close to the bridge at the Eastern exit from the village, banks of Maule river (35° 42' 20" / 71° 04' 38"); 6: Ñuble, Pinto, from Recinto to Ñuble National Reserve, Diguillín river (36° 53' 41" / 71° 37' 05"); 7: Ñuble, Quillón, Liucura, Banks of Itata river, at the junction point with Diguillín river (36° 51' 59" / 72° 22' 50"); 8: Bio-Bio, Alto Bio-Bio, from Ralco to Trapa-Trapa, Banks of Queuco river (37° 49' 52" / 71° 34' 18"); 9: Bio-Bio, Alto Bio-Bio, close to Ralco, Pangué river, near its junction with Bio-Bio river (37° 53' 48" / 71° 36' 59").

The main problem with recognising an association of Humboldt's willow (*Otholobio-Salicetum humboldtiana*), another provisional association of riparian scrublands without willows (*Baccharido-Myrceugenietum lanceolatae*) and another association of pioneering phreatophilic scrublands [*Tessario absinthioidis-Baccharidetum marginalis* Oberd. 1960, lectotypus Oberdorfer (1960): 40, Tb. 6, relevé 8] is their incorporation into syntaxonomical units of a higher order. Oberdorfer's proposal (*op. cit.*), which until now

we cited with the name of "*Salicetea chilena*", must be discarded for two reasons: a) in the first place because this proposal was included and used by Martínez-Carretero *et al.* (2016) in an attempt to defend the German author's proposal for Central Chile, but using Eskuche's highly controversial interpretation (2004) based on certain tropical formations on the banks of the River Paraná. Both Eskuche's proposal (*op. cit.*) and the subsequent proposal of Martínez-Carretero *et al.* (*op. cit.*) used the name of *Salicetea humboldtiana* (Oberd.

1960) Eskuche 2004 but without formalising the typification of their lower units or conforming to the precise standards of the ICPN. b) Second, because Oberdorfer's name is based simply on his Table 6 containing barely four relevés, whose association (*Tessario absinthioidis-Baccharidetum marginalis*)—due to its scant floristic content—we understand to correspond more closely to a class of phreatophilic scrublands described and defined in the Bolivian Andes, but whose biogeographic scope extends throughout the Chacoan, Tropical South Andean, Amazonian, Brazilian-Paranensean and Hyperdesertic Tropical Pacific regions (Navarro, 2011), and—in our opinion—also the Middle Chilean-Patagonian region. We therefore consider that “*Salicetea chilena*” should be rejected and a new and more appropriate name must be found.

Syntaxonomical references

The distribution of *S. humboldtiana* is very broad as it ranges from Central America (Mexico) and a large part of South America (San Martín & Véliz, 2006), and reaches its southernmost limits in La Araucanía in Chile (Hauenstein *et al.*, 2005) and Chubut in Argentina (Bozzi *et al.*, 2014). We have therefore sought to find phytosociological information on possible communities that could include riparian-phreatophilic formations, similar to those studied in Central Chile but from neighbouring territories in relatively close proximity. The minimum requirement was for this information to be supported by phytosociological relevés so we could use the set of companion plants to judge the degree of similarity or difference from the formations that we call here *Otholobio-Salicetum humboldtiana* and *Tessario-Baccharidetum marginalis*.

We were unable to find any publication with relevés on willow formations in Chile after the initial study by Oberdorfer (1960). It is also significant that similar willow formations are very scarce in the Argentinian part of the same biogeographical territory (the Middle Chilean-Patagonian region), to the point that the situation of *Salix humboldtiana* has recently led it to be classified as a threatened native species in Patagonia; in rivers like the Neuquén or Negro it is estimated to have lost considerable terrain due to the encroachment of exotic species, particularly of *Salix × rubens* (Bozzi *et al.*, 2014). The tree formations along its rivers are strongly influenced by long-standing anthropisation so that the main riparian tree formations to be found today are exotic—mainly European—willow stands. A good example is the study of the willow stands present in the Mendoza River located at a similar latitude to the region of Valparaíso (33° South) described by Méndez (1998) as an exclusive domain of *Salix fragilis*, *S. babylonica* and even *S. alba*, which is why this author includes these willow formations in the class *Salicetea purpureae*. It is significant that in a subsequent review this same author cites the presence of *S. humboldtiana* in Mendoza, but mainly as an ornamental plant cultivated in urban green areas, and he only cites one locality (Encón, Lavalle) where this willow was found growing spontaneously in the Mendoza River (Méndez, 2012).

We expanded the territorial search criteria, and Table 3 shows a comparison with various associations or communities described in territories adjoining Chile, namely Argentina, Bolivia and Peru. Their provenance can be seen more clearly on the biogeographical map in Figure 5. The following observations can be made regarding this set of communities:

- They all belong to territories in the Tropical Macrobioclimate, as they are located at a considerable distance (between 1400 and 2500 km) from the Central Chilean province and in more northerly positions.
- There is an appreciable heterogeneity in species richness between the different samples, as some are pioneering formations with very few species (col. 2: 5 spp./rel.) whereas others form far more biodiverse woodlands (col. 3: 29 spp./rel.).
- The groups of companion flora are clearly tropical in all cases (except col. 1, in Chile) so there is very little similarity between *Otholobio-Salicetum humboldtiana* and the other associations. The exceptions are *Salix humboldtiana* itself and *Baccharis salicifolia*, a very widespread shrub throughout South America but which is syntaxonomically affiliated to a more pioneering vegetation class, and is a dynamic precursor of the more established vegetation after the entry of Humboldt's willow.
- There are samples from tropical zones in the semiarid to the humid ombroclimate; but also from the hyper-arid territory (cols. 6, 7), which reveal rather more impoverished communities. Column 7 refers to a community with *Salix humboldtiana* as the only tree element accompanied by various helophytes, leading its authors to include it in the cosmopolitan class *Magnocarici-Phragmitetea* [*Phragmito-Magnocaricetea* as expressed literally in Galán de Mera *et al.* (2004)].
- There are also divergences in the syntaxonomical interpretation. The formations in the Tropical South Andean and Chacoan regions are recognised within the class *Salici humboldtiana-Prosopidetea albae* by Navarro & Maldonado (2002), who also interpret this class as reaching the Hyperdesertic Tropical Pacific region. However, the formations studied in this last region, in Peruvian hyper-arid territories (col. 6), were attributed by Galán de Mera *et al.* (2002) to another class, *Acacio macracanthae-Prosopidetea pallidae*, whose differentiation from the preceding class is under debate. The affiliation of the association in col. 2 can be conclusively dismissed; its Argentinian authors assigned a class *Salicetea humboldtiana*, which is clearly an invalid proposal as has been indicated previously (art. 5 ICPN).

In view of the differences in the companion flora in the various tropical willow formations shown in Table 3, we consider that Chilean associations in Table 1 (col. 1, Table 3) should be assigned to a different phytosociological class for which we propose the name and typification in Appendix 1.

Table 3. Communities or vegetation series of phreatophile woodlands with *Salix humboldtiana* (Chile and neighboring countries)

Territory	Coquimbo-Bio-Bio (Chile)	Parana River-Corrientes (Argentina)	Jujuy (Argentina)	Cochabamba-Potosí-Tarija (Bolivia)	Pando-Beni-Santa Cruz (Bolivia)	Ica-Lima (Peru)	Lima-Tacna (Peru)
Latitude S.	31° 44'–37° 49'	27° 18'–27° 27'	24° 09'–24° 21'	16° 00'–22° 12'	9° 50'–18° 10'	11° 53'–14° 39'	11° 55'–17° 50'
Biogeographic Region	Middle Chilean-Patagonian	Chacoan	Tropical South Andean	Tropical South Andean	Amazonian + Brazilian-Paranensean	Hyperdesertic Tropical Pacific	Hyperdesertic Tropical Pacific
Biogeographic Province	Central Chilean	North Chacoan	Bolivian-Tucumán	Bolivian-Tucumán	SW Amazonian + Benian+W Cerrado	Hyperdesertic North Peruvian	Hyperdesertic Tropical Chilean-Arequipán
Community	<i>Otholobio-Salicetum</i> + <i>Baccharido-Myrcogenietum</i>	<i>Tessaria integrifoliae-Salicetum humboldtianae nomen nudum</i>	<i>Salici humboldtianae-Acacietaum aromae</i>	<i>Pisoniella arborescens-Salicetum humboldtianae</i>	Riparian Macroseric <i>Tessaria integrifolia</i> & <i>Salix humboldtiana</i>	<i>Schino mollis-Acacietaum macracanthae</i>	<i>Equisetum gigantei-Salicetum humboldtianae</i>
Thermotype	Thermo+Meso Medit	Thermo Tropical	Meso Tropical	Thermo(Meso) Trop	Thermo Tropical	Thermo Tropical	Thermo Tropical
Ombrotpe	SemiArid–SubHumid (Humid)	SubHumid	SubHumid-Humid	Dry-SubHumid (Humid)	SubHumid – Humid	HyperArid-Arid	HyperArid-Arid
Relevés Source	Amigo <i>et al.</i> , present paper, Tab.1	Eskuche 2004	Entrocassi 2016	Navarro <i>et al.</i> 1996 Navarro 1997	Navarro 1997	Galán de Mera <i>et al.</i> 2002	Galán de Mera <i>et al.</i> 2004
N. relevés	22 + 4	5	2	.	.	12	4
N. spec./rel.	19–20	5	29	.	.	10	9
Characteristic species (underliamed = dominant trees or shrubs)	<i>Salix humboldtiana</i> <i>Otholobium glandulosum</i> <i>Myrcogenia lanceolata</i> <i>Mayrnesia boaria</i> <i>Escallonia myrtilloidea</i> <i>Aristotelia chilensis</i> <i>Luma chequen</i> Xenophytic trees	<i>Salix humboldtiana</i> <i>Tessaria integrifolia</i> <i>Solanum amygdalifolium</i> <i>Mikania periplocoifolia</i> <i>Funarium clausum</i> <i>Cissus palmata</i>	<i>Acacia aroma</i> <i>Salix humboldtiana</i> <i>Tessaria integrifolia</i> <i>Parapiptadenia excelsa</i> <i>Sebastiania brasiliensis</i> <i>Tecoma stans</i> <i>Baccharis salicifolia</i> <i>Tessaria dodoneifolia</i> <i>Urena baccifera</i>	<i>Salix humboldtiana</i> <i>Pisoniella arborescens</i> <i>Sapium glandulosum</i> <i>Acalypha plicata</i> <i>Schinus fasciculatus</i> <i>Caesalpinia spinosa</i> <i>Clematis denticulata</i> <i>Muehlenbeckia tamnifolia</i> <i>Tropaeolum bolivianum</i>	<i>Salix humboldtiana</i> <i>Tessaria integrifolia</i> <i>Acrostichum aureum</i> <i>Echinochloa polystachya</i> <i>Gynerium sagittatum</i>	<i>Acacia macracantha</i> <i>Schinus molle</i> <i>Prosopis pallida</i> <i>Parkinsonia aculeata</i> <i>Salix humboldtiana</i> <i>Tecoma arequipensis</i> <i>Pluchea chingoyo</i> <i>Baccharis salicifolia</i> <i>Tessaria integrifolia</i>	<i>Salix humboldtiana</i> <i>Baccharis salicifolia</i> <i>Equisetum giganteum</i> <i>Gynerium sagittatum</i> <i>Ptyrogramma trifoliolata</i>
Frequently companion species	<i>Equisetum bogotense</i> <i>Stemodia durantifolia</i> <i>Juncus dombeyanus</i> <i>Cortaderia selbaana</i> <i>Cyperus eragrostis</i> <i>Rhodosciarpus asper</i> <i>Classiss nova</i> <i>proposita</i> (present paper)	<i>Cissus sycioides</i>	<i>Polygonum punctatum</i> <i>Dicliptera squarrosa</i> <i>Paspalum distichum</i> <i>Alternanthera philoxeroides</i> <i>Asclepias curassavica</i>	<i>Baccharis salicifolia</i> <i>Tessaria absinthioides</i>	<i>Caesalpinia spinosa</i> <i>Vallisia glabra</i> <i>Bulnesia retama</i>	<i>Cynodon dactylon</i> <i>Polygona interruptus</i> <i>Melilotus indicus</i> <i>Sonchus oleraceus</i>	
Class	<i>Salicetea humboldtianae</i> "sensu Munez-Carretero <i>et al.</i>	" <i>Salicetea humboldtianae</i> " sensu Munez-Carretero <i>et al.</i>	<i>Salici humboldtianae-Prosopidetea albae</i>	<i>Salici humboldtianae-Prosopidetea albae</i>	<i>Salici-Prosopidetea albae</i> + <i>Tessario-Baccharidetea salicifoliae</i>	<i>Acacio macracanthae-Prosopidetea pallidae</i>	<i>Phragmito-Magnocaricetea</i>

Detailed studies of the vegetation in the Tropical South Andean region point to a distinction between the different geoseries in the communities of phreatophilic scrub or shrublands established on valley floors and riverplains where there is a permanent or seasonal accumulation of moisture in the soil, either on the surface or at accessible levels of the watertable. Several examples of associations described in Bolivian territory such as *Equiseto bogotensis-Tessarietum absinthioidis* or *Asclepio kuntzei-Baccharidetum salicifoliae* (e.g. Navarro *et al.*, 1996) in inter-Andean areas with a semiarid and dry ombroclimate are good representations of the class *Tessario integrifoliae-Baccharidetea salicifoliae*; we believe this syntaxonomical unit may be valid for integrating species-poor phreatophilic scrubland formations such as the Chilean community described by Oberdorfer (1960) which we cited previously as *Tessario absinthioidis-Baccharidetum marginalis*. Table 4 shows another comparison between this association and some examples extracted from Bolivian and Peruvian territories coinciding with others shown in Table 3.

If we only study the phreatophilic scrublands of the Central Chilean province, based on Oberdorfer's association (Table 4, col. 1) and our own relevés as shown in Table 2, we can interpret this as merely a species-poor facies, impoverished in comparison to *Otholobio-Salicetum humboldtiana*, corresponding to what some authors have opted to call a "basal community" (Kopecký & Hejný, 1974; Aguiar, 2000). However, the fact that associations have been detected, differentiated and described in other territories with similar ombroclimatic situations, and been assigned their own class (some of whose key species coincide with those found in Central Chile), leads us to consider as an acceptable solution the affiliation of *Tessario absinthioidis-Baccharidetum marginalis* within the class *Tessario integrifoliae-Baccharidetea salicifoliae*. Its area of distribution is thus enlarged to cover not only the Tropical territory but also the oceanic pluviseasonal Mediterranean territory.

Table 4. Associations of phreatophile shrublands included in *Tessario integrifoliae-Baccharidetea salicifoliae*

Territory	Middle Chile (Chile)	Middle Chile (Chile)	Cochabamba (Bolivia)	Lima-Tacna (Peru)
Latitude S.	32° 45' – 34° 47'	34° 03' – 37° 53'	17° 57' – 18° 43'	11° 40' – 17° 56'
Biogeographic Region	Middle Chilean-Patagonian	Middle Chilean-Patagonian	Tropical South Andean	Hyperdesertic Tropical Pacific
Biogeographic Province	Central Chilean	Central Chilean	Bolivian-Tucumán	Hyperdesertic North Peruvian + Hyperdesertic Tropical Chilean-Arequipán
Community	<i>Tessario absinthioidis</i> – <i>Baccharidetum marginalis</i>	<i>Tessario absinthioidis</i> – <i>Baccharidetum marginalis</i>	<i>Equiseto bogotensis-Tessarietum absinthioidis</i> + <i>Asclepio-Baccharidetum salicifoliae</i>	<i>Baccharido salicifoliae</i> – <i>Gynerietum sagittatae</i>
Thermotype	Thermo+Meso Medit	Thermo + Meso Medit	Thermotropical	Thermotropical
Ombrotype	SemiArid– SubHumid	SemiArid– SubHumid	SemiArid– Dry	HyperArid–Arid
Relevés Source	Oberdorfer, 1960	Amigo <i>et al.</i> , present paper, Tab. 2	Navarro <i>et al.</i> , 1996	Galán de Mera <i>et al.</i> , 2004
N. relevés	4	9	.	8
N. spec./rel.	7	10	.	9
Characteristic species (underlined = dominant shrubs)	<u><i>Baccharis salicifolia</i></u> <u><i>Tessaria absinthioides</i></u> <u><i>Salix humboldtiana</i></u> <u><i>Otholobium glandulosum</i></u>	<u><i>Baccharis salicifolia</i></u> <u><i>Otholobium glandulosum</i></u> <u><i>Tessaria absinthioides</i></u> <u><i>Salix humboldtiana</i></u> <u><i>Equisetum bogotense</i></u>	<u><i>Baccharis salicifolia</i></u> <u><i>Tessaria absinthioides</i></u> <u><i>Asclepias kuntzei</i></u> <u><i>Equisetum bogotense</i></u> <u><i>Pluchea sagittalis</i></u>	<u><i>Gynerium sagittatum</i></u> <u><i>Tessaria integrifolia</i></u> <u><i>Baccharis salicifolia</i></u> <u><i>Equisetum giganteum</i></u> <u><i>Salix humboldtiana</i></u>
Frequently companion species	<i>Cortaderia selloana</i> <i>Verbena litoralis</i> <i>Cyperus eragrostis</i>	<i>Cortaderia selloana</i> <i>Galega officinalis</i> <i>Salix babylonica</i>	<i>Nicotiana glauca</i>	<i>Phragmites australis</i> <i>Schinus molle</i> <i>Grindelia glutinosa</i>
Phytosociol. class	<i>Tessario integrifoliae-Baccharidetea salicifoliae</i>	<i>Tessario integrifoliae-Baccharidetea salicifoliae</i>	<i>Tessario integrifoliae-Baccharidetea salicifoliae</i>	<i>Magnocarici-Phragmitetea</i> *

* These authors do not recognize *Tessario-Baccharidetea salicifoliae* as an independent class but consider the order *Tessario-Baccharidetea salicifoliae* within *Magnocarici-Phragmitetea* class (= *Phragmito-Magnocaricetea* in literal expression of these authors).

Conclusions

A riparian phreatophilic community presided by *Salix humboldtiana* (Humboldt's willow) can be identified in the Central Chilean biogeographical province, recognisable in the thermo- and mesomediterranean thermotypes in semiarid to humid ombroclimates. It is recognised with the name of *Otholobio glandulosi-Salicetum humboldtiana* as a new association.

In humid areas near or encroaching on the Temperate macrobioclimate there is another riparian tree/shrub community that is syntaxonomically related with the previous association. In the absence of a greater number

of samples we assign it a provisional name: *Baccharido salicifoliae-Myrceugenietum lanceolatae*.

The comparison of these two associations with other Argentinian, Bolivian and Peruvian communities that are *a priori* similar due to the participation of *Salix humboldtiana* confirms the hypothesis that the Central Chilean formations should be included in a different phytosociological class: a Mediterranean class as opposed to the other samples, which are all tropical. We propose for this the name of *Mayteno boariae-Salicetea humboldtiana* (see the typification in the Appendix 1).

We identify the phreatophilic scrubland formations that occasionally appear as pioneering character community on

riverbanks or alluvial terraces in Central Chile, and which may represent a prior dynamic stage of the willow stand, with the association *Tessario absinthioidis-Baccharidetum marginalis* Oberdorfer 1960, whose syntaxonomical relations should be established by means of the class *Tessario integrifoliae-Baccharidetea salicifoliae*.

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Appendix 1. Phytosociological scheme

We include in this appendix all syntaxa cited in the text with their corresponding hierarchical ones. Typus and characteristic species are also indicated in the new syntaxa. European syntaxa follow the compilation and proposals of Mucina *et al.* (2016).

MAYTENO BOARIAE-SALICETEA HUMBOLDTIANAE Amigo, Flores-Toro & Caballero *class. nova hoc loco* (*holotypus* *Mayteno boariae-Salicetalia humboldtiana* Amigo, Flores-Toro & Caballero).

Characteristic species: the same as the order.

Mayteno boariae-Salicetalia humboldtiana Amigo, Flores-Toro & Caballero *ordo novo hoc loco* (*holotypus* *Mayteno boariae-Salicion humboldtiana* Amigo, Flores-Toro & Caballero).

Characteristic species: *Maytenus boaria*, *Salix humboldtiana*, *Luma chequen*, *Equisetum bogotense*, *Aristotelia chilensis*.

Mayteno boariae-Salicion humboldtiana Amigo, Flores-Toro & Caballero *all. nova hoc loco* (*holotypus*: *Otholobio glandulosi-Salicetum humboldtiana* Amigo, Flores-Toro & Caballero).

Characteristic species: *Otholobium glandulosum*, *Salix humboldtiana*, *Stemodia durantifolia* var. *chilensis*, *Rhodoscirpus asper*, *Juncus dombeyanus*, *Discaria trinervis*.

Otholobio glandulosi-Salicetum humboldtiana Amigo, Flores-Toro & Caballero *ass. nova hoc loco* (*holotypus*: Tab. 1, rel. 11).

Baccharido salicifoliae-Myrceugenietum lanceolatae *ass. nova prov.*

Escallonion illinito-myrtioideae Amigo, Flores-Toro & Caballero *all. nova hoc loco* (*Escallonion illinito-myrtioideae* *all. prov.* Amigo & Flores-Toro 2017).

(*holotypus*: *Mayteno boariae-Escallonietum illinitae* Amigo & Flores-Toro 2017, *Int. J. Geobot. Res.* 7: 120).
 Characteristic species: *Escallonia illinita*, *Escallonia myrtoidea*, *Buddleja globosa*, *Equisetum bogotense*,
Tropaeolum tricolor, *Azara dentata*.

Mayteno boariae-Escallonietum illinitae Amigo & Flores-Toro 2017 *ass. nova hoc loco* (*holotypus* Amigo & Flores-Toro 2017, *Int. J. Geobot. Res.* 7: 116s; Tab. 5, rel. 1).

Buddlejo globosae-Escallonietum myrtoideae Amigo & Flores-Toro 2017 *ass. nova hoc loco* (*holotypus* Amigo & Flores-Toro 2017, *Int. J. Geobot. Res.* 7: 118s; Tab. 6, rel. 5).

SALICETEA PURPUREAE Moor 1958

LITHRAEO CAUSTICAE-CRYPTOCARYETEA ALBAE Oberd. 1960

PHRAGMITO-MAGNO-CARICETEA Klika in Klika & Novák 1941 *nom. inv.*

SALICI HUMBOLDTIANAE-PROSOPIDETEA ALBAE Riv.-Mart. & Navarro in Navarro & Maldonado 2002

ACACIO MACRACANTHAE-PROSOPIDETEA PALLIDAE Galán de Mera 1999

TESSARIO INTEGRIFOLIAE-BACCHARIDETEA SALICIFOLIAE Riv.-Mart. & Navarro in Navarro & Maldonado 2002

WINTERO-NOTHOFAGETEA Oberd. 1960

Myrceugenietalia exsuccae Oberd. 1960 corr. Amigo & Rodríguez Guitián 2011

Myrceugenion exsuccae Oberd. 1960

Myrceugenio pinifoliae-Tepualietum stipularidis (San Martín J, San Martín C & Ramírez 2001) *ass. nova*
 (*lectotypus*: *Myrceugenio-Tepualietum stipularidis* San Martín J, San Martín C & Ramírez 2001, *Rev. Geogr. Chile Terra Australis* 46: 18s; Tab. 5, rel. 7).