The case of the Itata estuary (Bio-Bio Region-Chile) plant formations: anthropogenic interference or natural disturbance-induced diversity enrichment?

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Abstract. The current study examined the relationship between native and introduced plant species, as indicators of the state of anthropogenic influence on plant formations in the area of the Itata estuary (Bio-Bio Region, Chile). A total of 186 vegetation samples were collected in different plant communities in the wetlands and adjacent areas of the Itata River during 2011 and 2012. The communities of four terrestrial plant formations were sampled within dunes, prairies, shrub lands and food crops, and within two aquatic habitats (freshwater and salt marsh). The total flora comprised of 222 species, these were dominated by introduced taxa with thirty-three species considered invasive for Chile. The high percentage contribution of these alien weeds to the total community could be interpreted as signs of a strong degree of anthropogenic interference in the natural plant formations. However, some habitats such as salt marshes are subjected to periodic natural disturbances (e.g. tsunamis), lacking human interference. Consequently, in some habitats, alien species, which are more resilient, represent the primary plant formations.

Keywords: Coastal wetlands; salt marsh; disturbances; plant formations; flora; neophytes.

Introduction

One of the great utopian desires of human beings is to return to the past. The common notion is that in the past everything was better because the environment was in a pristine state, undisturbed, and landscape destruction and contamination were not an issue. This heavenly-like perception was already well displayed in Don Quixote’s speech thanking the goatherds (Cervantes, 2004). However, parallel with the evolution of hominids, a continuous modification and alteration of the natural, pristine environment took place in order to facilitate human life, and with these changes began the process of anthropogenic landscape transformation (Lovelock, 2000; Frey & Loesch, 2010). This process, speeded up by the technical revolution, has led to large-scale environmental destructions, causing a general imbalance in the biogeochemical cycles that led to the extinction of species, often harming dominant species the most (Kaufman & Harries, 1996; Barnoski & al., 2012; Pott, 2013). One could also speculate that before Homo sapiens, the extinction of dinosaurs was self-inflicted, as this mass extinction might have been caused by their massive impact on the environment. As Margalef (1996)
stated, perhaps so many complacent meteorites are not necessary to produce extinction.

Nevertheless, assuming a pristine state of the earth, or at least a state without human interference, is central to assess levels of ecological landscape degradation. This assumption has important consequences for the conservation of species, their habitats and their ecological interactions in order to understand the magnitude of damage environmental alterations may cause. Thus, particularly a dominant species’ ecology such as its activity affects biodiversity, which in turn is central to maintain ecosystem stability (Streit, 2007; Schulze & al., 2002; MacDougall & al. 2013).

Rather pristine landscapes in sparsely populated locations enable the study of plant communities, which represent the zero point of an anthropogenic induced degradation process and others, which represent different degrees of alteration. This facilitates the assessment of degradation processes, its stages of secondary succession and, consequently, the understanding what might have caused these state changes (Ramírez & al., 1994; Ramírez & al., 2016; San Martin & al., 2014; Alarcón, 2014).

The original, pristine communities without human intervention are considered primary and their stands represent the reference point in respect to landscape degradation. In Chile, these primary communities were mainly forests between the Aconcagua River (Valparaiso Region) and the Magellan Strait (Reiche, 2013). The anthropogenic processes, which are the ‘slash and burn’ strategies, give rise to the development of secondary communities. In the case of forests, these secondary communities correspond to shrub communities (secondary thickets), from which the original forest could be regenerated, in the absence of other disturbances such as cattle grazing. Generally, it is known that cattle grazing induce the development of a secondary prairie community (Alarcón, 2014). If the latter is overgrazed and further degraded, it will be populated by invasive shrub species, forming a tertiary shrub community. This tertiary community does not allow a potential regeneration of the original forests. The main changes of the flora and vegetation in this degradation process are outlined in Figure 1. However, ironically stated, human interference can also diversify the landscape by giving rise to secondary and tertiary communities that in turn increase floristic biodiversity, because of the introduction of alien weeds (Murphy & Romanuk, 2004; Richardson & al., 2000; Sandoval & al., 2016).

The present study is a floristic survey of the plant formations of a coastal wetland in South Central Chile affected by frequent natural disturbances. Our study was based on the assumption that in such disturbed habitats, the presence of alien species would not necessarily be a consequence of human interference (Figure 1) changing the perception that alien species reflect secondary and tertiary conditions. Our aim was to identify, characterise the flora, including alien species, inhabiting six plant formations within different habitats in the area of the Itata estuary (Bio-Bío Region, Chile). We also evaluated the life forms within those plant formations and assessed the scale of human interference using different indexes of landscape degradation.

Material & Methods

Study sites

The study sites comprised the plant formations inhabiting dunes, a salt marsh, prairies, shrub lands, freshwater and food crops within the estuary of the Itata River (Nuble province, Bio-Bío Region, Chile) (Figure 2). A sand bar at the estuary’s mouth reduces the surface flow of the river (except during periods of high water), where the estuary expands into a large lagoon which gives rise to a salt marsh. The estuary consists of a narrow water channel between dunes, flanked by the sector of Boca Itata (36°22’28”S-72°50’50” W) to the North and Las Vegas del Itata (36°24’0”S-72°50’57”W) to the South (Figure 2).

The climate of this region is oceanic temperate with Mediterranean influence. The climatic diagram of Punta Tumbes (36°37’59”S-73°06’57”W), 12 km north of the city of Talcahuano, shows a marked seasonality with long winters characterised by high precipitation and short but dry summers (Hajek & Di Castri, 1975) (Figure 2). The annual average monthly temperature reaches 12.3°C with an average maximum and minimum of 15.6°C and 9°C, respectively. The climate in this region can be considered humid Meso-Mediterranean with annual precipitation reaching 829 mm (Amigo & Ramírez, 1998). Depending on the topography, the original forest vegetation along the coastal zone of the Bio-Bío Region was formed in depressions characterised by water-logged soil of swamp forests of the Temo-Pitra association (Temo-Myrceugenietum exsuceae) and at elevated locations by partially sclerophyllous forests dominated by roble (Nothofagus obliqua) of the Nothofago-Perseetum boldestosum association (Oberdorfer, 1960). However, both communities were destroyed and have been replaced by “junquillo” wet grassland association (Juncetum procerii) biotopes and sclerophyllous shrubs, such as “boldo” (Peumus boldus) and “yelmo” (Griselinia racemosa), respectively (Ramírez & al., 2014).
Moreover, the boundary hedges of the roads in that zone are presently covered by invasive blackberry bushes (*Rubus-cestretum parquii*) (Amigo & al., 2007). The surrounding land of the estuary hosts large plantations of *Pinus radiata* and *Eucalyptus globulus*.

The sand dunes were covered with vegetation on both sides of the estuary. The salt marsh was characterised by brackish swamps exhibiting extreme conditions under the tidal influence. On the other hand, the prairies, which were located inland, were anthropogenic formations used for cattle grazing. The shrub lands consisted of secondary plant communities, which originated from anthropogenic destruction of the primitive sclerophyllous forest vegetation and the introduction of blackberry shrubs as hedges on roadsides. The aquatic vegetation in freshwater habitats comprised the free water zone of saltwaters and the boggy zones near riverbanks. The food crops were mainly cereals and potatoes.

Figure 2. The Itata River estuary (Bio-Bio Region, Chile) located in the Central South of Chile. Inset: Ombrothermic diagram of Punta Tumbes (modified from Hajek & Di Castri, 1975); x-axis displays months from July to June; left y-axis represents temperature (°C) and right y-axis precipitation (mm). Continuous and broken lines shows monthly precipitation (mm) and temperature (°C). Dotted and lined areas shows dry (arid period, P<2T) and wet months. Black areas indicate months with precipitation over 100 mm.
Sampling

The present study represents an assessment of the terrestrial and aquatic vegetation of the northern and southern reaches of the Itata river mouth, applying the phytosociological methodology of Southern Europe (Braun-Blanquet, 1979; Dengler & al., 2008).

A total of 186 sample units of vegetation were surveyed from all distinguishable plant communities at the southern estuary reach (Las Vegas del Itata) as well as from the dunes present on both sides of the estuary. The study comprises six plant formations with 30 communities (plant associations) (Table 1). The latter will be analysed in a forthcoming publication. The differentiation of plant formations was based on the biological spectra and environmental conditions depicted in Table 1 following Schmithüsen (1968).

Table 1. Number of plant associations and number of vegetation samples raised for each plant formation studied in the work place.

| Plant formation | Plant associations | Samples |
|-----------------|-------------------|---------|
| Aquatic         | 8                 | 21      |
| Dunes           | 6                 | 63      |
| Salt marshes    | 6                 | 54      |
| Shrubs          | 2                 | 19      |
| Prairie         | 5                 | 29      |
| Crops           | 3                 | 0       |
| **Total (6)**   | **30**            | **186** |

In the spring and summer, 2011 and 2012, surveys were carried out on 25 m² (5x5m) plots arranged within the six plant formations (see Table 1). For each sample unit of vegetation, the list of plant species present in the plot was first noted, followed by a subsequent abundance estimation of each species in the plots, represented as total percentage cover (Dierschke, 1994). For plants with less than 1% cover, we used a “r” symbol to denote the presence of several individuals of a species, and the “+” symbol to indicate the presence of a single individual of a species (Knapp, 1984). These symbols were later changed to a unit of one to facilitate further calculations.

Unknown plant species were collected, dried and preserved in a herbarium to aid later identification, using the taxonomic literature (Ramírez & al., 1989; Matthei, 1995; Ramírez & Álvarez, 2017; Ramírez & San Martín, 2006). These preserved specimens were deposited in the VALD Herbarium of the Universidad Austral de Chile (Valdivia-Chile). The nomenclature was updated following the Plant List website (http://www.theplantlist.org) while their native or introduced status followed the assessment of Zuloaga & al. (2008).

The classification into large groups considered the dicotyledons, including the basal Angiosperms and the Magnoliidae. Life forms were assigned using the key of Mueller-Dombois & Ellenberg (1974). The proportion of life forms including phanerophytes (woody plants), chamaephytes (subshrubs), hemicyryptophytes (perennial plants) and therophytes (annual and biannual plants) were used to depict biological spectra following the approach of Raunkiaer (1937). The classification into invasive species was based on Fuentes & al. (2014). The stages of anthropogenic modifications followed those defined in González (2000), Schroeder (1998), Frey & Loesch (2010) and Steinhardt & al. (1999).

Results

Classification of the introduced and native flora

A total of 222 plant species were identified from the northern and southern reaches of the Itata estuary (Appendix 1). Among those species, only 44.15% were native plants while the remainder (55.85%) was composed of alien species (Table 2, Figure 3). The angiosperms widely dominated with 219 species (98.65%) the plant formations, while the dicotyledonous (in a wider sense) were more abundant (148 species, 66.66%) than monocotyledonous species (71 species, 31.98%). The gymnosperms were represented by a single, introduced species used for forest plantations, Pinus radiata D. Don (‘Pino insignis’) and two ferns: Adiantum chilense Kaulf. (‘Culantrillo’) and Azolla filiculoides Lam. (‘Flor del pato’) (Table 2, Appendix 1). A. chilense inhabits the understory of forests and shrub lands, while A. filiculoides is a floating aquatic plant.

Figure 3. Percentage contribution of introduced and native plant species in the area of the Itata estuary (Bio-Bio Region, Chile).

The 222 plant species are distributed in 165 genera and 65 families. The species-richest genus is Juncus with seven species, followed by the genera Ranunculus and Trifolium, each with four species, and ten genera (Acacia, Carex, Cyperus, Hordeum, Lolium, Lythrum, Plantago, Polygonum, Rumex and Salix) each with three species. However, most genera (153) were represented with either two or one species. When considering species richness among families, the Poaceae (grasses), Fabaceae (legumes), Asteraceae (composites) and Cyperaceae dominated with 38, 19, 18 and 13 species, respectively. Nevertheless, if the number of species of the Cichorioideae (5 species), a subfamily of the composites...
is added to the Asteraceae, the latter becomes the second species-richest family with 23 species. Furthermore, the families of Scrophulariaceae were represented with eight, both the Juncaceae, and the Polygonaceae with seven, the Apiaceae (Umbelliferae) with six, and both the Chenopodiaceae and Cichoriaceae with five species. More than three-quarters (84.61%) of all families were represented with fewer than five species (Appendix 1).

Table 2. Origin, classification and biological spectrum of the flora at the study area.

| Phytogeographic origin | Species | Percentage |
|------------------------|---------|------------|
| Introduced             | 124     | 55.86      |
| Natives                | 98      | 44.14      |
| Total                  | 222     | 100        |

Classification groups

| Dicotyledons           | 148     | 66.67      |
| Monocotyledons         | 71      | 31.98      |
| Gymnosperms            | 1       | 0.45       |
| Ferns                  | 2       | 0.90       |
| Total                  | 222     | 100        |

Life forms

| Phanerophytes          | 33      | 14.86      |
| Chamaephytes           | 23      | 10.36      |
| Hemicyryptophytes      | 86      | 38.74      |
| Cryptophytes           | 23      | 10.36      |
| Therophytes            | 57      | 25.68      |
| Total                  | 222     | 100        |

Biological spectrum

The biological spectrum was dominated by hemicyryptophytes (perennial plants) with 86 species (38.74%) and therophytes (annual and biannual plants) with 57 (25.68%) species (Table 2). Thus, both herbaceous life forms include 143 species (64.42%), while all other plant life forms including the phanerophytes (woody plants), chamaephytes (sub-bushes and erect grasses) and cryptophytes have fewer species (see Table 2).

The biological spectrum found at the estuary of the Itata River does not represent any typical phytoclimate but demonstrated altered vegetation at the study sites. In particular, the high percentages of annual plants (therophytes) and perennial (hemicyryptophytes) groups that incorporated only neophytes indicate a high degree of anthropogenic modification of the flora.

Plant formations

The species-richest plant formations were found in the dunes (98 species, 44.14%) and in the prairies (97 species, 43.69%), respectively. Slightly fewer plant species were identified in the aquatic habitats (74 species, 33.33%), the shrub lands (68 species, 30.63%) and the salt marsh (52 species, 23.42%). As expected, food crops were the species-poorest habitat (14 species, 6.31%), comprising cultivated plants and weeds (Table 3).

Comparing the commonness of plant species among the different habitats, revealed that 115 species occurred in one, 55 in two, 35 in three and 12 in four plant formations (Table 3). Four non-native weed species (*Lupinus arboreus*, *Plantago lanceolata*, *Anthemis cotula* and *Calystegia sepium*) occurred in all but one plant formation, indicating a strong anthropogenic influence. In contrast, only one species, *Galega officinalis*, occurred in all of them (Table 3).

**Introduced and native species within plant formations**

All plant formations were dominated (> 50%) by introduced species (Figure 4). This high percentage implies a perturbed plant community altering plant formations. Only within the studied shrubs and freshwaters, native species reached 50% of the whole plant communities. Only food crops, as expected, were dominated by introduced species (Figure 4).

**Plant life forms within plant formations**

Among plant life forms, the phanerophytes (woody plants) were most abundant in the plant formations of the shrub lands (27 species, Table 4, Figure 5). Particularly in dunes and in freshwater habitats, this group dominated over other life forms. Near freshwaters, they were represented by introduced species such as *Salix babylonica*, *S. viminalis* and *Alnus glutinosa* and the native *Salix humboldtiana*. In all other plant formations, the woody plants played a minor role while being absent in the food crops. In the dunes, the contribution in species number (15) by the chamaephytes (sub-shrubs) to the plant formation was higher than in all other studied habitats (Table 4, Figure 5).

The hemicyryptophytes (perennial weeds) dominated in the plant formations of four habitats (dunes, salt marsh, prairies and freshwater) with the highest number of species (46) in the prairies. The highest number of cryptophytes species (17) was found in freshwater habitats including swamps. Geophytes, a subgroup of the cryptophytes, reached the highest number of species (6) in the prairies. In contrast, this group was only represented by one species (*Alium vineale*) in the food crops and was missing in the salt marsh.
Table 3. Presence of the species in the plant formations ordered by frequency (Freq.). ‘1’ indicates presence of the species.

| Species                        | Dune | Marshes | Prairie | Shrubs | Aquatic | Crops | Freq. |
|--------------------------------|------|---------|---------|--------|---------|-------|-------|
| Galega officinalis             | 1    | 1       | 1       | 1      | 1       | 1     | 6     |
| Lupinus arboreus               | 1    | 1       | 1       | 1      | 1       |       | 5     |
| Plantago lanceolata            | 1    | 1       | 1       | 1      | 1       |       | 5     |
| Anthemis cotula                | 1    | 1       | 1       | 1      | 1       |       | 5     |
| Calystegia sepium              | 1    | .       | 1       | 1      | 1       | 1     | 5     |
| Agrostis capillaris            | 1    | 1       | 1       | 1      | 1       |       | 4     |
| Cotula coronopifolia           | 1    | 1       | 1       | .      | 1       |       | 4     |
| Leontodon saxatilis            | 1    | 1       | 1       | 1      | .       |       | 4     |
| Raphanus raphanistrum          | 1    | 1       | 1       | 1      | .       |       | 4     |
| Rumex acetosella               | 1    | 1       | 1       | 1      | 1       |       | 4     |
| Rumex conglomeratus            | 1    | 1       | 1       | 1      | 1       |       | 4     |
| Scirpus americanus             | 1    | 1       | 1       | 1      | .       |       | 4     |
| Xanthium spinosum              | 1    | 1       | 1       | 1      | .       |       | 4     |
| Barbarea verna                 | 1    | 1       | 1       | .      | 1       |       | 4     |
| Convolvulus arvensis           | 1    | .       | 1       | 1      | .       |       | 4     |
| Digitaria sanguinalis          | 1    | 1       | 1       | 1      | .       |       | 4     |
| Polygonum persicaria           | 1    | 1       | 1       | .      | 1       |       | 4     |
| Cichorium intybus              | 1    | .       | 1       | 1      | .       |       | 3     |
| Eleocharis pachycarpa          | 1    | 1       | 1       | .      | 1       |       | 3     |
| Lotus corniculatus             | 1    | 1       | 1       | .      | .       |       | 3     |
| Muehlenbeckia hastulata        | 1    | .       | 1       | 1      | .       |       | 3     |
| Polypogon australis            | 1    | 1       | 1       | 1      | .       |       | 3     |
| Triglochin concinna            | 1    | 1       | 1       | 1      | .       |       | 3     |
| Acacia caven                   | 1    | .       | 1       | 1      | .       |       | 3     |
| Acacia dealbata                | 1    | .       | 1       | 1      | .       |       | 3     |
| Agrostis stolonifera           | 1    | .       | 1       | 1      | .       |       | 3     |
| Alnus glutinosa                | 1    | .       | 1       | 1      | .       |       | 3     |
| Alstroemeria hookeriana        | 1    | .       | 1       | 1      | .       |       | 3     |
| Anthemis arvensis              | 1    | 1       | 1       | .      | .       |       | 3     |
| Atriplex chilenissis           | 1    | 1       | 1       | .      | .       |       | 3     |
| Atriplex patula                | 1    | .       | 1       | 1      | .       |       | 3     |
| Carex fiscula                  | 1    | .       | 1       | 1      | .       |       | 3     |
| Chenopodium album              | 1    | .       | 1       | 1      | .       |       | 3     |
| Chenopodium ambrosioides       | 1    | 1       | 1       | 1      | .       |       | 3     |
| Holcus lanatus                 | 1    | 1       | 1       | 1      | .       |       | 3     |
| Juncus balticus                | 1    | 1       | 1       | 1      | .       |       | 3     |
| Juncus microcephalus           | 1    | .       | 1       | 1      | .       |       | 3     |
| Juncus planifolius             | 1    | .       | 1       | 1      | .       |       | 3     |
| Lythrum hyssopifolia           | 1    | 1       | 1       | 1      | .       |       | 3     |
| Medicago hispida               | 1    | 1       | 1       | 1      | .       |       | 3     |
| Paspalum dilatatum             | 1    | .       | 1       | 1      | 1       |       | 3     |
| Plantago truncata              | 1    | 1       | 1       | .      | .       |       | 3     |
| Rumex sanguineus               | 1    | 1       | 1       | 1      | .       |       | 3     |
| Salix babylonica               | 1    | .       | 1       | 1      | 1       |       | 3     |
| Salix humboldtiana             | 1    | .       | 1       | 1      | 1       |       | 3     |
| Salix viminalis                | 1    | .       | 1       | 1      | 1       |       | 3     |
| Selliera radicans              | 1    | 1       | 1       | .      | .       |       | 3     |
| Spergularia rubra              | 1    | 1       | 1       | .      | .       |       | 3     |
| Stemodia durantifolia          | 1    | 1       | 1       | 1      | .       |       | 3     |
| Conium maculatum               | 1    | .       | 1       | 1      | .       |       | 3     |
| Euphorbia portulacoides        | 1    | .       | .       | 1      | 1       |       | 3     |
| Saponaria officinalis          | 1    | 1       | 1       | .      | .       |       | 3     |
| Distichlis spicata             | 1    | 1       | .       | .      |       |       | 2     |
| Hordeum chilensis              | 1    | 1       | .       | .      |       |       | 2     |
| Carduus pycnocephalus          | 1    | .       | 1       | .      | .       |       | 2     |
| Species                        | Dune | Marshes | Prairie | Shrubs | Aquatic | Crops | Freq. |
|-------------------------------|------|---------|---------|--------|---------|-------|-------|
| Hypochaeris radicata          | 1    | 1       |         |        |         |       | 2     |
| Alstroemeria ligtu             | 1    |         | 1       |        |         |       | 2     |
| Ambrosia chamissonis          | 1    | 1       |         |        |         |       | 2     |
| Anagallis arvensis             | 1    |         | 1       |        |         |       | 2     |
| Arrhenatherum elatius          |      |         |         | 1      |         |       | 2     |
| Aster squamatus                |      | 1       | 1       |        |         |       | 2     |
| Baccharis racemosa             |      | 1       |         |        |         |       | 2     |
| Bellardia trisago              |      | 1       | 1       |        |         |       | 2     |
| Bromus catharticus             |      | 1       | 1       |        |         |       | 2     |
| Carex pumila                   | 1    |         |         | 1      |         |       | 2     |
| Cirsium vulgare                |      |         |         |        |         |       | 2     |
| Cynodon dactylon               |      | 1       |         |        |         |       | 2     |
| Cyperus rotundus               |      |         | 1       |        |         |       | 2     |
| Daucus carota                  |      | 1       |         | 1      |         |       | 2     |
| Festuca rubra                  |      | 1       | 1       |        |         |       | 2     |
| Foeniculum vulgare             |      |         | 1       |        |         |       | 2     |
| Glandularia corymbosa          |      | 1       |         |        |         |       | 2     |
| Juncus pallescens              |      | 1       |         |        |         |       | 2     |
| Lagurus ovatus                 | 1    |         | 1       |        |         |       | 2     |
| Lathyrus sativus               |      |         |         |        |         |       | 2     |
| Lolium temulentum              | 1    |         |         |        |         |       | 2     |
| Lythrum maritimum              |      | 1       |         |        |         |       | 2     |
| Lythrum portula                |      | 1       |         |        |         |       | 2     |
| Margryricarpus pinnatus        | 1    |         | 1       |        |         |       | 2     |
| Melilotus albus                |      |         | 1       |        |         |       | 2     |
| Mentha pulegium                |      | 1       |         |        |         |       | 2     |
| Myoporos laetus                | 1    |         |         |        |         |       | 2     |
| Peumus boldus                  |      |         | 1       |        |         |       | 2     |
| Phyla nodiflora                | 1    |         |         |        |         |       | 2     |
| Plantago hispidula             |      | 1       | 1       |        |         |       | 2     |
| Polygonum hydropiperoides      |      |         | 1       |        |         |       | 2     |
| Polygonum sanguinaria          | 1    | 1       |         |        |         |       | 2     |
| Populus nigra                  |      | 1       |         |        |         |       | 2     |
| Rubus ulmifolius               | 1    |         |         | 1      |         |       | 2     |
| Salsola kali                   | 1    |         |         |        |         |       | 2     |
| Schoenoplectus californicus    |      | 1       |         |        |         |       | 2     |
| Sisymbrium officinale          | 1    |         |         |        |         |       | 2     |
| Solanum nigrum                 |      |         | 1       |        |         |       | 2     |
| Sporobulus indicus             | 1    |         |         |        |         |       | 2     |
| Stenotaphrum secundatum        |      | 1       |         |        |         |       | 2     |
| Vulpia bromoides               | 1    |         |         |        |         |       | 2     |
| Xanthium eavanillessii         | 1    |         |         |        |         |       | 2     |
| Anthoxanthum urticulatum       |      |         | 1       |        |         |       | 2     |
| Crepis capillaris              | 1    |         |         |        |         |       | 2     |
| Cyperus eragrostis             |      |         | 1       |        |         |       | 2     |
| Hordeum murinum                | 1    |         |         |        |         |       | 2     |
| Juncus bufonius                | 1    |         |         | 1      |         |       | 2     |
| Oldenlandia salzmannii         |      | 1       |         |        |         |       | 2     |
| Ranunculus muricatus           |      |         |         |        |         |       | 2     |
| Tetragonia maritima            | 1    |         |         |        |         |       | 2     |
| Trifolium angustifolium        | 1    |         |         |        |         |       | 2     |
| Cyperus rigens                 |      |         | 1       |        |         |       | 1     |
| Ludwigia peploides             |      |         |         |        |         |       | 1     |
| Callitriche terrestris         |      |         |         |        |         |       | 1     |
| Panicum urvilleanum            |      |         |         |        |         |       | 1     |
| Parentucellia viscosa          |      |         |         |        |         |       | 1     |
| Species                  | Plant formations |
|--------------------------|------------------|
| Typha dominguensis       | 1                |
| Acacia melanoxylon       | 1                |
| Acena ovalifolia         | 1                |
| Acmispon subpinnatus     | 1                |
| Adesmia filifolia        | 1                |
| Adesmia visida           | 1                |
| Adiantum chilense        | 1                |
| Aria caryophyllea        | 1                |
| Alisma lanceolatum       | 1                |
| Allium vineale           | 1                |
| Ammophila arenaria       | 1                |
| Arctotheca calendula     | 1                |
| Aristotelia chilensis    | 1                |
| Azara integrifolia       | 1                |
| Azollia filiculoides     | 1                |
| Bidens aurea             | 1                |
| Brassica rapa            | 1                |
| Briza maxima             | 1                |
| Briza minima             | 1                |
| Bromus hordeaceus        | 1                |
| Calceolaria integrifolia | 1                |
| Calystegia soldanella    | 1                |
| Carex riparia            | 1                |
| Carpobrotus chilensis    | 1                |
| Cestrum parqui           | 1                |
| Chusquea cumingii        | 1                |
| Cissus striata           | 1                |
| Coniza bonariensis       | 1                |
| Cuscuta suaveolens       | 1                |
| Cynosurus echinatus      | 1                |
| Datura stramonium        | 1                |
| Echium plantagineum      | 1                |
| Eryngium paniculatum     | 1                |
| Escallonia pulverulenta  | 1                |
| Eucalyptus nitens        | 1                |
| Francoa appendiculata    | 1                |
| Fuchsia magellanica      | 1                |
| Gamochaeta americana     | 1                |
| Griselinia racemosa      | 1                |
| Hordeum jubatum          | 1                |
| Hydrocotyle bonariensis  | 1                |
| Hypericum perforatum     | 1                |
| Isolepis cernus          | 1                |
| Isolepis inmundatus      | 1                |
| Jovellana violacea       | 1                |
| Juncus imbricatus        | 1                |
| Juncus procerus          | 1                |
| Lactuca serriola         | 1                |
| Lemna valdiviana         | 1                |
| Libertia chilensis       | 1                |
| Lilaeopsis macloviana    | 1                |
| Limosella australis      | 1                |
| Lithraea caustica        | 1                |
| Lobelia tupa             | 1                |
| Lolium multiflorum       | 1                |
| Lolium perenne           | 1                |
| Species                  | Dune | Marshes | Prairie | Shrubs | Aquatic | Crops | Freq. |
|--------------------------|------|---------|---------|--------|---------|-------|-------|
| Lotus uliginosus         | 1    | .       | .       | .      | 1       | .     | 1     |
| Lupinus microcarpus      | 1    | .       | .       | .      | .       | .     | 1     |
| Medicago polymorpha      | .    | .       | 1       | .      | .       | .     | 1     |
| Melilotus indicus        | .    | 1       | .       | .      | .       | .     | 1     |
| Mentha aquatica          | .    | .       | .       | .      | 1       | .     | 1     |
| Mimulus briggessii       | .    | .       | .       | .      | 1       | .     | 1     |
| Myosotis arvensis        | .    | .       | .       | .      | 1       | .     | 1     |
| Myriophyllum aquaticum   | .    | .       | .       | .      | 1       | .     | 1     |
| Myriophyllum quitense    | .    | .       | .       | .      | 1       | .     | 1     |
| Nolana paradoxa          | 1    | .       | .       | .      | .       | .     | 1     |
| Notanthera heterophylla  | .    | .       | 1       | .      | .       | .     | 1     |
| Nothoscordum bivalve     | 1    | .       | .       | .      | .       | .     | 1     |
| Noticastrum sericeum     | .    | 1       | .       | .      | .       | .     | 1     |
| Oenothera stricta        | .    | .       | .       | .      | 1       | .     | 1     |
| Otholobium glandulosum   | .    | .       | .       | .      | 1       | .     | 1     |
| Oxalis corniculata       | .    | .       | 1       | .      | .       | .     | 1     |
| Oxalis perdicaria        | 1    | .       | .       | .      | .       | .     | 1     |
| Parapholis incurva       | .    | 1       | .       | .      | .       | .     | 1     |
| Parapholis strigosa      | .    | 1       | .       | .      | .       | .     | 1     |
| Paspalum distichum       | 1    | .       | .       | .      | .       | .     | 1     |
| Phragmites australis     | .    | .       | .       | 1      | .       | .     | 1     |
| Phyla canescens          | 1    | .       | .       | .      | .       | .     | 1     |
| Pinus radiata            | .    | .       | .       | 1      | .       | .     | 1     |
| Piptochaetium montevidense | .     | .     | 1       | .      | .       | .     | 1     |
| Poa lanuginosa           | 1    | .       | .       | .      | .       | .     | 1     |
| Polypogon monspeliensis  | .    | .       | .       | .      | 1       | .     | 1     |
| Potamogeton berteroanus   | .    | .       | .       | .      | 1       | .     | 1     |
| Stuckenia pectinata      | .    | .       | .       | .      | 1       | .     | 1     |
| Potamogeton pusillus      | .    | .       | .       | .      | 1       | .     | 1     |
| Proustia pyrifolia       | .    | .       | 1       | .      | .       | .     | 1     |
| Puccinellia glaucescens   | .    | 1       | .       | .      | .       | .     | 1     |
| Ranunculus bonariensis   | .    | .       | .       | .      | 1       | .     | 1     |
| Ranunculus chilensis     | .    | .       | .       | .      | 1       | .     | 1     |
| Ranunculus minutiflorus  | .    | .       | .       | .      | 1       | .     | 1     |
| Rhodophiala chilensis    | .    | .       | .       | .      | 1       | .     | 1     |
| Rosa rubiginosa           | .    | .       | .       | .      | 1       | .     | 1     |
| Sambucus nigra           | .    | .       | .       | .      | 1       | .     | 1     |
| Sarcocornia fraticosa    | .    | 1       | .       | .      | .       | .     | 1     |
| Scirpus olneyii          | 1    | .       | .       | .      | .       | .     | 1     |
| Scrophularia auriculata  | .    | .       | .       | .      | .       | 1     | 1     |
| Senecio chilensis        | .    | .       | .       | .      | 1       | .     | 1     |
| Sesycos bryonifolius     | .    | .       | .       | .      | 1       | .     | 1     |
| Sonchus oleraceus        | .    | .       | .       | .      | 1       | .     | 1     |
| Srachys grandidentata    | .    | .       | .       | .      | 1       | .     | 1     |
| Teline mospessulana      | .    | .       | .       | .      | 1       | .     | 1     |
| Tetragonia espinosae     | 1    | .       | .       | .      | .       | .     | 1     |
| Trifolium dubium         | .    | .       | .       | .      | 1       | .     | 1     |
| Trifolium pratense       | .    | .       | .       | 1      | .       | .     | 1     |
| Trifolium repens         | .    | .       | 1       | .      | .       | .     | 1     |
| Tweedia hirostrata       | 1    | .       | .       | .      | .       | .     | 1     |
| Ugni molinae             | .    | .       | .       | .      | 1       | .     | 1     |
| Uncinia phleoides        | .    | .       | .       | .      | 1       | .     | 1     |
| Verbascum thapsus        | .    | .       | .       | 1      | .       | .     | 1     |
| Verbena corymbosa        | .    | .       | .       | .      | 1       | .     | 1     |
| Veronica anagallis-aquatica | .    | .   | .       | .      | .       | 1     | 1     |
| **Total species:**        | 98   | 52      | 97      | 68     | 74      | 14    | 403   |
Figure 5. Comparison of the biological spectrum (by number of species) in the plant formations determined in the study area.

The annual and biannual life forms (therophytes) were common in all studied habitats, reaching their highest species number in dunes and prairies (29 species each; Table 4). In addition, they were only represented with one species in the crops and were absent in the salt marsh. Finally, therophytes (annual and biennial plants) are abundant in all formations, but especially in dunes and prairies each with 29 species (Table 4, Figure 5).

Comparing the percentage contribution of each life form within each plant formation demonstrated that the chamaephytes were evenly represented across the dune, salt marsh and food crop habitats (Table 5). Similarly well represented were the hemicryptophytes in the plant formations of the salt marsh, prairies and freshwater (Table 5). In contrast, phanerophytes and therophytes dominated the plant formations in the shrub lands and food crops, respectively (Table 5). The cryptophytes, on the other hand, were only well represented in the freshwater habitats, while the therophytes reached a high percentage contribution among all plant life forms in the dunes and dominated in the food crops.

Table 4. Biological spectra according to the number of species by life form of study area plant formations.

| Life forms     | Plant formations |
|----------------|------------------|
|                | Dunes | Marsh | Prairie | Shrubs | Aquatic | Crops |
| Phanerophytes  | 11    | 2     | 9       | 27     | 8       | 0     |
| Chamaephytes   | 15    | 8     | 7       | 2      | 4       | 2     |
| Hemicryptophytes| 38    | 24    | 46      | 20     | 35      | 3     |
| Cryptophytes   | 3     | 0     | 6       | 3      | 17      | 1     |
| Therophytes    | 29    | 18    | 29      | 16     | 10      | 8     |
| Total          | 96    | 52    | 97      | 68     | 74      | 14    |

Table 5. Biological spectra according to the species by life form in the study area plant formations.

| Life forms     | Plant formations |
|----------------|------------------|
|                | Dunes | Marshs | Prairies | Shrubs | Aquatic | Crops |
| Phanerophytes  | 11,45 | 3,85  | 9,28    | 39,71  | 10,81   | 0     |
| Chamaephytes   | 17,35 | 15,38 | 7,22    | 2,94   | 5,41    | 14,29 |
| Hemicryptophytes| 39,58 | 46,15 | 47,42   | 29,41  | 47,3    | 21,43 |
| Cryptophytes   | 5,1   | 6,19  | 4,41    | 22,97  | 7,14    |       |
| Therophytes    | 30,21 | 34,62 | 29,9    | 23,53  | 13,51   | 57,14 |
| Total          | 100   | 100   | 100     | 100    | 100     | 100   |

Invasive plants

Thirty-three species of the 124 introduced ones could be considered invasive (Tables 6 and 7). These constitute species that invade natural and anthropogenic altered ecosystems, changing the floristic structure of the existing plant communities.

The biological spectrum of this group is dominated by the therophytes with 48% (16 species) followed by the phanerophytes and hemicryptophytes (8 species each), while cryptophytes are only represented by one invasive aquatic species, Veronica anagallis-aquatica.
Table 6. Invasive plant species determined in the work place. It indicates Scientific name, classification, life forms and presence in Chile. Abbreviations: Gr: Classification group (D: Dicotyledon, M: Monocotyledon, G: Gymnosperm, H: Fern); LF: Life form (F: Fanerophyte, C: Chamaephyte, H: Hemicryptophyte, Cr: Cryptophyte, T: Terophyte).

| Scientific name          | Gr | LF | Place of invasion in Chile |
|--------------------------|----|----|----------------------------|
| Acacia dealbata          | D  | F  | Valparaiso to Valdivia     |
| Acacia melanoxylon       | D  | F  | Valparaiso to Chiloé       |
| Agrostis capillaris      | M  | H  | Coquimbo to Magallanes     |
| Alnus glutinosa          | D  | F  | Bio-Bio to Valdivia        |
| Bromus hordeaceus        | M  | T  | Coquimbo to Magallanes     |
| Carduus pycnocephalus    | D  | T  | Valparaiso to Puerto Montt  |
| Cirsium vulgare          | D  | T  | Coquimbo to Magallanes     |
| Conium maculatum         | D  | T  | Coquimbo to Aysén          |
| Convolvulus arvensis     | D  | H  | In continental chile       |
| Crepis capillaris        | D  | T  | Atacama to Magallanes      |
| Cynosurus echinatus      | M  | T  | Valparaiso to Magallanes   |
| Datura stramonium        | D  | T  | Arica to Temuco            |
| Daucus carota            | D  | T  | Valparaiso to Chiloé       |
| Echium plantagineum      | D  | H  | Rancagua to Temuco         |
| Galega officinalis       | D  | H  | Valparaiso to Osorno       |
| Holcus lanatus           | M  | T  | Coquimbo to Magallanes     |
| Hordeum murinum          | M  | T  | Atacama to Magallanes      |
| Lagurus ovatus           | M  | T  | Coquimbo to Magallanes     |
| Leontodon saxatilis      | D  | H  | Valparaiso to Aysén        |
| Lotus corniculatus       | D  | T  | Santiago to Chiloé         |
| Lupinus arboreus         | D  | F  | Coquimbo to Aysén          |
| Medicago polymorpha      | D  | T  | Arica to Puerto Montt       |
| Pinus radiata            | G  | F  | Coquimbo to Valdivia       |
| Polygonum persicaria     | D  | T  | Chile continental          |
| Rosa rubiginosa           | D  | F  | Valparaiso to Aysén        |
| Rubus ulmifolius         | D  | F  | Valparaiso to Temuco       |
| Rumex acetosella         | D  | H  | In continental Chile       |
| Sisymbrium officinale    | D  | T  | In continental Chile        |
| Teline mosspessulana     | D  | F  | Valparaiso to Osorno       |
| Trifolium repens         | D  | H  | Chile continental          |
| Verbascum thapsus        | D  | T  | Valparaiso to Aysén        |
| Veronica anagallis-aquatica | D  | Cr | In continental Chile       |

Table 7. Biological spectrum of the invasive species. Number of species and percentage are indicated.

| Life forms      | Species | Percentage |
|-----------------|---------|------------|
| Phanerophytes   | 8       | 24,24      |
| Chamaephytes    | 0       | 0,00       |
| Hemicryptophytes| 8       | 24,24      |
| Cryptophytes    | 1       | 3,03       |
| Therophytes     | 16      | 48,48      |
| Total           | 33      | 100,00     |

Discussion

The high species richness, in total 222 plant species, within the studied sites of the Itata estuary was expected, particularly when considering the vegetation diversity of six plant formations and 30 plant associations (see Table 1). However, this high floristic diversity was mostly due to the
presence of angiosperms, which in turn comprised a high number of neophytes. The latter evidences a high degree of anthropogenic alterations of the environment. This result contrasts with a rather balanced biological spectrum (among life forms between 10.36 and 38.74%). In the Itata estuary, both the scare remnants of the original forest flora and numerous invasive plants are characterised by phanerophytes. Among the species of the biological spectrum, sub-shrubs (chamaephytes) thrive in extreme environmental conditions (Raunkiaer, 1937: Cain, 1950). Among the habitats they inhabit in the area of the estuary are the dunes that are a nutrient poor, wind-swept, and, therefore, an unstable environment with little water retention. The other habitat colonised by sub-shrubs is the salt marsh, with a substrate of silt and organic matter, exposed to tidal water level changes. The weed representatives of therophytes and hemicryptophytes reflect a high anthropogenic alterations of the plant formations (Peña-Cortés & al., 2006), although a strong to very strong anthropogenic impact could be allowed their future dispersal into other plant communities, thus, altering further their present species composition.

In particular, according to the proposed scheme of González (2000) shown in Table 8, a strong anthropogenic influence on the Itata’s estuary plant formations can be depicted, since more than 30% of the plant assemblages (Figure 4) are constituted by neophyte species. Consequently, all studied plant formations are impacted and were in a stage of secondary or tertiary plant formation. Similarly, a strong to very strong anthropogenic impact could be deduced from the degree of hemeroby following Sukopp (1976), Dierschke (1994) and Schroeder (1998) (see Table 9). This index considers three parameters, which include the percentage composition of neophytes, therophytes and the loss of native species, to allow an impact assessment. Thus, the studied plant formations can be depicted as eu- and polyhemeroby with an absence of the original plant formation (Peña-Cortés & al., 2006), although a lower number of therophyte species (annual plants) may be the consequence that part of the studied area covers wetlands.

Table 8. Degrees of human intervention according to the presence of neophytes in plant communities after González (2000).

| Grade | Neophyten (%) | Intervention |
|-------|---------------|--------------|
| 1     | < 13          | Nothing      |
| 2     | 14 - 20       | Little       |
| 3     | 21 - 30       | Medium       |
| 4     | > 30          | Strong       |

Table 9. Hemeroby grades in the plant communities (see text). Abbreviations are: G: Grade; Int: Intervention; Neo: Neophyten; Ther: Therophyten; Ln: Loos of native. Data on percentage.

| G | Hemeroby | Int | Neo | Ther | Ln |
|---|----------|-----|-----|------|----|
| 1 | Ahemeroby| Null| 0   | <20  | 0  |
| 2 | Oligohemeroby| Weak| <5  | <20  | <1 |
| 3 | Mesohemeroby| Medium| 5-12| <20  | >1 |
| 4 | Euhemeroby| Strong| 13-22| 21-30| >10|
| 5 | Polyhemeroby| Very strong| >22| >40 | >50|
| 6 | Metahemeroby| Total| 100 |

However, some neophyte species that occurred in the salt marsh and in dunes might have reached Chilean shores by dispersing over long distances such as via sea-currents (Ramírez & Romero, 1978). Examples of those species found in dunes and prairies comprised Ambrosia chamissonis, Arctothesca calendula, Atriplex patula, Lagurus ovatus, Lupinus arboreus, L. microcarpum, Sporobolus indicus and Stenophtymum secundatum. In freshwaters and brackish biotopes, these neophytes dispersed by sea currents included Barbarea verna, Cotula coronopifolia, Distichlis spicata, Ludwigia peploides, Parapholis incurva, P. strigosa, Polygonum hydropiperoides, Rumex sanguineus and Salsola kali.

Further to the south of Chile, possible archephytes from Europe and New Zealand are the species Potentilla anserina, Hebe elliptica and H. salicifolia. In addition, the neophyte Spartina densiflora might have an Atlantic origin (Ramírez & Romero, 1978) although Zuloaga & al. (2008) and Bortolus (2006) considered it as native to Chile.

As suggested by Ramírez et al. (1989), and defined by Walter (1997), the Chilean coastal wetlands and in particular the plant formations in dunes and salt marshes could be considered ‘native azonal primary communities’, despite the dominance of non-native plant species. The native plants that would able to colonize such extreme environments (i.e. sandy soils) are absent (Ramírez & al., 1992b; 2012). The lack of original plant formations in these zones is puzzling as no succession in degradation processes could be observed when compared to other environments (Ramírez & al., 2014; 2016).

As a consequence of this lack of native plant populations, wind- and water-dispersed seeds of alien species could colonise these coastal habitats, forming ‘autochthonous’ assemblages. Remarkable is the high resilience of these neophytes (and some native species) as they are able to withstand high levels of natural disturbances including surface gravity waves, mud intrusions, earthquake induced permanent water level changes and saline intrusions due to tsunamis (Valdovinos & al., 2012). Furthermore, the lack of Chilean native species may also be attributed to the expansion of coastal dunes since the early 20th century. This dune development extending to the southern parts of Chile might have in part its origins in bad soil management linked to agricultural practices (Ramírez & al., 1992b). In Chile, salt marshes are older in origin
but are also affected by natural disturbances such the flooding after tsunamis (González & al., 2012), but not by human interference.

Conclusions

Although human interference plays a big role in the alteration of original plant formations, the number of introduced plant species is not necessarily a good indicator of direct anthropogenic landscape manipulations. In particular, the azonal communities of the Itata salt marsh and its dunes, were dominated by alien, resilient species withstanding frequent natural disturbances. This may suggest that these assemblages constitute the primary communities of these habitats.

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### Appendix 1. Nomenclature and taxonomic status of the plant species found in the estuary of the Itata River (Bío-Bío Region, Chile). The data includes phytogeographic origin and life forms. Abbreviations are: Gr: Classification group (D: Dicotyledon, M: Monocotyledon, G: Gymnosperms, H: Ferns), PO: Phytogeographic origin (N: Native, I: Introduced), LF: Life forms (F: Phanerophytes, C: Chamaephytes, H: Hemicryptophytes, Cr: Cryptophytes, T: Therophytes). The species are arranged alphabetically.

| Scientific name (and author) | Family | Local name | Gr | PO | LF |
|-----------------------------|--------|------------|----|----|----|
| Acacia caven (Molina) Molina| Mimosaceae | Espino maulino | D | N | F |
| Acacia dealbata Link.        | Mimosaceae | Aromo blanco | D | I | F |
| Acacia melanoxylon R. Br.    | Mimosaceae | Aromo australiano | D | I | F |
| Acaena ovalifolia Ruiz & Pav.| Rosaceae | Trun, Cadillo | D | N | H |
| Acmsipon subpinnatus (Lag.) D.D. Sokoloff | Fabaceae | Porotillo | D | N | T |
| Adesmia filifolia            | Fabaceae | Paramela | D | N | C |
| Adesmia viscosa Savi         | Fabaceae | Paramela | D | N | C |
| Adiantum chilense Kaufl.     | Adiantaceae | Culantrillo | H | N | F |
| Agrostis capillaris L.       | Poaceae | Chépica | M | I | H |
| Agrostis stolonifera L.      | Poaceae | Chépica rastrera | M | I | H |
| Aira caryophylla L.          | Poaceae | Aira | M | I | T |
| Ailmsa lanceolatum With.     | Alismataceae | Llantén de agua | M | N | H |
| Allium vineale L.            | Liliaceae | Cebolleta | M | I | T |
| Alnus glutinosa (L.) Gaerth. | Betulaceae | Aliso | D | I | F |
| Alstroemeria hookeriana Schult. & Schult. f. | Alstroemeriaceae | Amancay | M | N | Cr |
| Alstroemeria ligu L.         | Alstroemeriaceae | Liuto | M | N | Cr |
| Ambrosia chamissonis (Less.) Greene | Asteraceae | Dicha grande | D | I | C |
| Anagallis arvensis L.        | Primulaceae | Anmofila | M | I | H |
| Anthemis arvensis L.         | Asteraceae | Manzanillón | D | I | T |
| Anthemis cotula L.           | Asteraceae | Manzanillón | D | I | T |
| Anthoxanthum utriculatum (Ruiz & Pav.) Schouten & Veldk. | Poaceae | Paja ratonera | M | N | H |
| Arctotheca calendula (L.) Levyss | Asteraceae | Filigrana | D | I | H |
| Aristotelia chilensis (Molina) Stuntz. | Elaeocarpaceae | Maqui | D | N | T |
| Arrhenatherum elatius (L.) | Poaceae | Pasto cebolla | M | I | H |
| Aster squamatus (Spreng.) Hieron. | Asteraceae | Bellorita de pantano | D | N | H |
| Atriplex chilensis Colla | Chenopodiaceae | Cachiyuyo | D | N | C |
| Atriplex patula L.           | Chenopodiaceae | Cachiyuyo | D | I | T |
| Azara integriofolia Ruiz & Pav. | Flacourtiaaceae | Corcolen | D | N | F |
| Azolla filiculoides Lam.     | Azollaceae | Flor del pato | H | N | Cr |
| Baccharis racemosa (Ruiz & Pav.) DC. | Asteraceae | Chica | D | N | F |
| Barbarea verna (Mill.) Aschers. | Brassicaceae | Berro amarillo | D | I | T |
| Bellardia trixago (L.) All.  | Orobanchaceae | Pegagos | D | I | T |
| Bidens aurea (Aiton) Sherff | Asteraceae | Falso té | D | I | C |
| Brassica rapa L.             | Brassicaceae | Yuyo | D | I | T |
| Briza maxima L.              | Poaceae | Bolitas del toro | M | I | T |
| Briza minima L.              | Poaceae | Tembleque | M | I | T |
| Bromus catharticus Vahl.     | Poaceae | Lanco | M | N | H |
| Bromus hordeaceus L.         | Poaceae | Lanco | M | I | T |
| Calceolaria integrifolia L.  | Scrophulariaceae | Topa-Topa | D | N | C |
| Callitriche terrestres Raf.  | Callitrichaceae | Huenchecó | D | N | H |
| Calystegia sepium (L.) R. Br. | Convolvulaceae | Suspiro de pantano | D | I | Cr |
| Calystegia soldanella R. Br. | Convolvulaceae | Suspiro | D | N | C |
| Carduus pycnocephalus L.     | Asteraceae | Cardo | D | I | T |
| Carex fuscata D’Urv.         | Cyperaceae | Cortadera | M | N | H |
| Carex pumiifl. Thumb.         | Cyperaceae | Cortadera de arena | M | N | H |
| Carex riparia Curtis         | Cyperaceae | Cortadera azul | M | N | H |
| Carpobrotus chilensis (Molina) N. E. Br | Aizoaceae | Doca | D | N | H |
| Cestrum parqui (Lam.) L’Her. | Solanaceae | Palqui | D | N | F |
| Chenopodium album L.         | Chenopodiaceae | Quinguilla | D | I | T |
| Chenopodium ambrosioides L.  | Chenopodiaceae | Paico | D | I | T |
| Chusquea cunningii Nees.     | Poaceae | Colilhuito | M | N | H |
| Cichorium intybus L.         | Cichoriaceae | Viburera | D | I | H |
| Cirsium vulgare (Savi) Ten   | Asteraceae | Cardo negro | D | I | T |
| Cissus striata Ruiz & Pav.   | Vitaceae | Voqui naranjillo | D | N | F |
| Conium maculatum L.          | Apiaceae | Cicuta | D | I | T |
| Scientific name (and author)                  | Family          | Local name          | Gr | PO | LF |
|----------------------------------------------|-----------------|---------------------|----|----|----|
| Coniza bonariensis (L.) Cronq.                | Asteraceae      | Conisa              | D  | I  | H  |
| Convolvulus arvensis L.                      | Convolvulaceae  | Correhuela          | D  | I  | H  |
| Cotula coronopifolia L.                      | Asteraceae      | Botón de oro africano | D | I  | H  |
| Crepis capillaris (L.) Wallr                 | Asteraceae      | Crepis              | D  | I  | T  |
| Cuscuta suaveolens Ser.                      | Convolvulaceae  | Cabellos de angel   | D  | N  | T  |
| Cynodon dactylon (L.) Pers.                  | Poaceae         | Pata de gallina     | M  | I  | T  |
| Cynusus echinatus L.                         | Poaceae         | Cebadilla           | M  | I  | T  |
| Cyperus eragrostis Lam                       | Cyperaceae      | Cortadera grande    | M  | N  | H  |
| Cyperus rigens J. Presl. & C. Presl.         | Cyperaceae      | Cortadera           | M  | N  | H  |
| Cyperus rotundus L.                          | Cyperaceae      | Chufa               | M  | I  | H  |
| Datura stramonium L.                         | Solanaceae      | Chamico             | D  | I  | T  |
| Daucus carota L.                             | Apiaceae        | Pata de pollo       | M  | I  | H  |
| Digitaria sanguinalis (L.) Scop.             | Poaceae         | Pata de pollo       | M  | I  | H  |
| Distichlis spicata (L.) Greene               | Poaceae         | Pato salado         | M  | N  | H  |
| Echium plantagineum L.                       | Boraginaceae    | Vibirera            | D  | I  | H  |
| Eleocharis pachycarpa E. Desv.               | Cyperaceae      | Rime                | M  | N  | H  |
| Eryngium paniculatum Cav. & Dombey ex F. Delaroche | Apiaceae        | Cardoncillo         | D  | N  | H  |
| Escallonia vulgaris (Raiz & Pav.) Pers.       | Asteraceae      | Barraco             | D  | N  | F  |
| Eucalyptus nitens (H. Deane & Maiden) Maiden | Myrtaceae       | Eucalipto           | D  | I  | F  |
| Euphorbia polychaumoides L.                  | Euphorbiaceae   | Pichoga de arena    | D  | I  | C  |
| Festuca rubra L.                             | Poaceae         | Festuca             | M  | I  | H  |
| Foeniculum vulgare Mill.                    | Apiaceae        | Hinojo              | D  | I  | H  |
| Francoa appendiculata Cav.                   | Saxifragaceae   | Llapaungue          | D  | N  | H  |
| Fuchsia magellanica Lam.                     | Onagraceae      | Chiclo              | D  | N  | F  |
| Galega officinalis L.                        | Fabaceae        | Galega              | D  | I  | H  |
| Gamochaeta americana (Mill.) Wedd.           | Asteraceae      | Vira-Vira           | D  | N  | H  |
| Glandularia cymbosa Ruiz & Pav. N.O.’Leary & Peralta | Verbenaceae    | Verbena             | D  | N  | H  |
| Griselina racemosa (Phil.) Taub.             | Cornaceae       | Lamulahuen          | D  | N  | F  |
| Holcus lanatus L.                            | Poaceae         | Pato dulce          | M  | I  | H  |
| Hordeum chilensis Roem. et Schult.           | Poaceae         | Cebadilla           | M  | N  | H  |
| Hordeum jubatum L.                           | Poaceae         | Cebadilla           | M  | I  | H  |
| Hordeum murinum L.                           | Poaceae         | Cebadilla           | M  | I  | T  |
| Hydrocotyle bonariensis Comm. ex Lam.        | Apiaceae        | Tembladerilla       | D  | I  | H  |
| Hypericum perforatum L.                      | Hypericaceae    | Hierba de San Juan  | D  | I  | T  |
| Hypochaeris radicata L.                      | Cichoriaceae    | Hierba del chanco   | D  | I  | H  |
| Isolepis cernua (Vahl) Roem. & Schult.       | Cyperaceae      | Can-Cán            | M  | N  | H  |
| Isolepis inundata R. Br.                     | Cyperaceae      | Chan-Chán          | M  | N  | Cr |
| Jovellana violacea (Cav.) G. Don.            | Scrophulariaceae| Topa-Topa azul     | D  | N  | H  |
| Juncus balticus Wildl.                       | Juncaceae       | Junquillo marino    | M  | I  | T  |
| Juncus bufonius L.                           | Juncaceae       | Junquillo           | M  | I  | T  |
| Juncus imbricatus Lah.                       | Juncaceae       | Junquillo duro      | M  | N  | H  |
| Juncus microcephalus Kunth                   | Juncaceae       | Junquillo rojo      | M  | N  | H  |
| Juncus pallescens Lam.                       | Juncaceae       | Hierba de la vaca   | M  | N  | H  |
| Juncus planifolius R. Br.                    | Juncaceae       | Junquillo pasto     | M  | I  | H  |
| Juncus procerus E. Mey.                      | Juncaceae       | Junquillo           | M  | N  | H  |
| Lactuca serriola L.                          | Cichoriaceae    | Brújula             | D  | I  | T  |
| Lagurus ovatus L.                            | Poaceae         | Unknown             | M  | I  | T  |
| Lathyrus sativus L.                          | Fabaceae        | Arvejilla           | D  | I  | T  |
| Lemna valdiviana Phil.                       | Lemnaceae       | Lenteja de agua     | M  | N  | Cr |
| Leontodon saxatilis Lam.                     | Cichoriaceae    | Chinilla            | D  | I  | H  |
| Libertia chilensis (Molina) Gunckel          | Iridaceae       | Calle-Calle         | M  | N  | H  |
| Lilaeopsis macloviana (Gaud.) A.W. Hill.     | Apicaceae       | Lilaiopsis          | D  | N  | Cr |
| Limosella australis R. Br.                   | Scrophulariaceae| Limosela            | D  | N  | Cr |
| Lithraea caustica (Molina) Hook. & Arn.      | Anacardiaceae   | Lire                | D  | N  | F  |
| Lobelia tapa L.                              | Lobeliaceae     | Tabaco del diablo   | D  | N  | H  |
| Lolium multiflorum Lam.                      | Poaceae         | Ballica             | M  | I  | H  |
| Lolium perenne L.                            | Poaceae         | Ballica             | M  | I  | T  |
| Lolium temulentum L.                         | Poaceae         | Ballica             | M  | I  | T  |
| Lotus corniculatus L.                        | Fabaceae        | Lotera              | D  | I  | T  |
| Lotus uliginosus Schkuhr.                    | Fabaceae        | Alfalfa chilota     | D  | I  | H  |
| Scientific name (and author) | Family                  | Local name          | Gr | PO | LF |
|------------------------------|-------------------------|---------------------|----|----|----|
| Ludwigia peploides (Kunth) P. H. Raven | Onagraceae | Clavito de agua | D  | I  | Cr |
| Lupinus arboreus Sims.       | Fabaceae                | Chollo              | D  | I  | F  |
| Lupinus microcarpus Sims.    | Fabaceae                | Chohito             | D  | I  | C  |
| Lythrum hyssopifolia L.      | Lythraceae              | Romerillo acuático | D  | I  | T  |
| Lythrum maritimum Kunth      | Lythraceae              | Romerillo           | D  | N  | T  |
| Lythrum portula (L.) D.A. Webb. | Lythraceae | Romerillo rojo     | D  | I  | H  |
| Margricarpus pinnatus (Lam.) Kuntze | Rosaceae | Perilla             | D  | N  | C  |
| Medicago hispida Gaertn.     | Fabaceae                | Alfalfa             | D  | I  | T  |
| Medicago polymorpha L.       | Fabaceae                | Hualputra           | D  | I  | T  |
| Melilotus albus Medik.        | Fabaceae                | Trebol dulce        | D  | I  | T  |
| Melilotus indicus (L.) All.   | Fabaceae                | Trevillo            | D  | I  | T  |
| Mentha aquatica L.            | Lamiaceae               | Hierba buena        | D  | I  | C  |
| Mentha pulegium L.            | Lamiaceae               | Polo                | D  | I  | C  |
| Mimusulus bridgessii Clos.    | Scrophulariaceae        | Berro               | D  | N  | H  |
| Muehlenbeckia hastulata (Sm.) I.M. Johnst. | Polygonaceae | Mollaca             | D  | N  | F  |
| Myoporum laetus Forst.        | Myoporaceae             | Mioporo             | D  | I  | F  |
| Myosotis arvensis L.          | Boraginaceae            | Nomeolvides         | D  | I  | T  |
| Myriophyllum aquaticum (Vell.) Verdc. | Haloragaceae | Pinito de agua     | D  | N  | Cr |
| Myriophyllumiquitenus Kunth   | Haloragaceae            | Pinito de agua      | D  | N  | Cr |
| Nolana paradoxa Lindl.        | Nolaneae                | Suspiro             | D  | N  | C  |
| Notanthera heterophylla (Ruiz & Pav.) G. Don | Santalaceae | Quintral del boldo | D  | N  | F  |
| Notochordus bivalve (L.) Britton | Iridaceae | Huilli              | M  | N  | Cr |
| Noticastrum sericeum (Less.) Less. ex Phil. Phil. | Asteraceae | Unknown            | D  | N  | H  |
| Oenothera stricta Ledeb. Ex Link. | Onagraceae | Diego de la noche  | D  | I  | T  |
| Oldenlandia salzmannii (DC.) Benth & Hook.f. ex B.D. Jacks. | Rubiaceae | Oldenlandia        | D  | N  | H  |
| Otholobium glandulosum (L.) J.W. Grimes | Fabaceae | Culén               | D  | N  | F  |
| Oxalis corniculata L.         | Oxalidaceae             | Hierba de la perdiz| D  | I  | T  |
| Oxalis perdicaria (Molina) Bertero | Oxalidaceae | Vinagrillo         | D  | N  | Cr |
| Panicum urvilleanum Kunth.    | Poaceae                 | Pasto peludo        | M  | N  | H  |
| Parapholis incurva (L.) C.E. Hubb. | Poaceae | Pasto alacran       | M  | I  | T  |
| Parapholis strigosa (Dumort.) C. E. Hubb. | Poaceae | No conocido        | M  | I  | T  |
| Parentucellia viscosa (L.) Caruel | Plantaginaceae | Pegagosa           | D  | I  | T  |
| Paspalum dilatatum Poir.      | Poaceae                 | Chépica ancha       | M  | I  | H  |
| Paspalum distichum L.         | Poaceae                 | Chépica angosta     | M  | I  | H  |
| Peumus boldus Molina          | Monimiaceae             | Boldo               | D  | N  | F  |
| Phragmites australis (Cav.) Trin. ex Steud. | Poaceae | Maicillo           | M  | N  | Cr |
| Phyla canescens (Kunth) Greene | Verbenaceae             | Hierba de la virgen| D  | I  | H  |
| Phyla reptans (Kunth) Greene  | Verbenaceae             | Hierba de la virgen| D  | I  | H  |
| Pinus radiata D. Don          | Pinaceae                | Pino insignie       | G  | I  | F  |
| Piptochaetium montevdense (Spreng.) Parodi | Poaceae | Quilmén            | M  | I  | H  |
| Plantago hispida Ruiz. & Pav. | Plantaginaceae          | Unknown             | D  | N  | H  |
| Plantago lanceolata L.        | Plantaginaceae          | Siete venas         | D  | I  | H  |
| Plantago truncata Cham. & Schidl. | Plantaginaceae | Llantén             | D  | N  | H  |
| Poa lanuginosa Poir.          | Poaceae                 | No conocido         | M  | N  | H  |
| Polygonon hydropiperoides Michx. | Polygonaceae | Duraznillo de agua | D  | I  | Cr |
| Polygonon persicaria L.       | Polygonaceae            | Duraznillo          | D  | I  | T  |
| Polygonon sanguinaria Remy    | Polygonaceae            | Sanguinaria         | D  | N  | C  |
| Polygonon australis Bronn    | Poaceae                 | Cola de zorro       | M  | N  | H  |
| Polygona montepelensis (L.) desf. | Poaceae | Cola de zorro      | M  | I  | H  |
| Populus nigra L.              | Salicaceae              | Alamo               | D  | I  | F  |
| Potamogeton berteranus Phil.  | Potamogetonaceae        | Huiro rojo          | M  | N  | Cr |
| Potamogeton pusillus L.       | Potamogetonaceae        | Huiro rojo          | M  | N  | Cr |
| Proustia pyrifolia DC.        | Astereaceae             | Tola blanca         | D  | N  | F  |
| Puccinellia glaucescens (Phil.) Parodi | Poaceae | Pasto azul         | M  | N  | H  |
| Ranunculus bonariensis Poir.  | Ranunculaceae           | Botón de oro        | D  | N  | H  |
| Ranunculus chilensis DC.      | Ranunculaceae           | Botón de oro        | D  | N  | H  |
| Ranunculus minitiflorus Burt. ex Phil. | Ranunculaceae | Botón de oro chico | D  | N  | H  |
| Ranunculus muricatus L.       | Ranunculaceae           | Hierba del guante   | D  | I  | H  |
| Raphanus raphanistrum L.      | Brassicaceae            | Rabanito            | D  | I  | T  |
| Rhodophiala chilensis (L.‘Her.) Traub. | Amaranthaceae | Añañuca             | M  | N  | Cr |
| Scientific name (and author) | Family | Local name | Gr | PO | LF |
|------------------------------|--------|------------|----|----|----|
| Rosa rubiginosa L. | Rosaceae | Rosa mosqueta | D | I | F |
| Rubus ulmifolius Schott. | Rosaceae | Zarzamora | D | I | F |
| Rumex acetosella L. | Polygonaceae | Romacilla | D | I | H |
| Rumex conglomeratus Murr. | Polygonaceae | Romaza roja | D | I | C |
| Salix babylonica L. | Salicaceae | Sauce llorón | D | I | F |
| Salix humboldtiana Willd | Salicaceae | Sauce amargo | D | N | F |
| Salix viminalis | Salicaceae | Sauce mimbre | D | I | F |
| Salsola kali L. | Chenopodiaceae | Salcolal | D | I | F |
| Sambucus nigra L. | Caprifoliaceae | Sauco | D | I | F |
| Saponaria officinalis L. | Caryophyllaceae | Jabonera | D | I | T |
| Sarcocornia fruticosa (L.) A. J. Scott. | Amaranthaceae | Hierba sosa | D | N | C |
| Schoenoplectus americanus (Pers.) Volkart | Cyperaceae | Totora azul | M | N | H |
| Scirpus olenii A. Grey ex Engelm. et Gray | Cyperaceae | Totora | M | N | Cr |
| Scrophularia auriculata L. | Scrophulariaceae | Unknown | D | I | T |
| Selliera radicans Cav. | Goodeniaceae | Maleza de marisma | D | N | H |
| Senecio chilensis Less. | Asteraceae | Palo de yegua | D | N | F |
| Sicyos bryoniifolius Moris | Cucurbitaceae | Calabacillo | D | I | F |
| Sisymbrium officinale (L.) Scop. | Brassicaceae | Mostacilla | D | I | T |
| Solanum nigrum | Solanaceae | Yaguecillo | D | I | T |
| Sonchus oleraceus L. | Cichoraceae | Ñilhue | D | I | T |
| Sporobolus indicus (L.) R. Br. | Caryophyllaceae | Taizana | D | I | C |
| Stachys grandidentata Lindl. | Poaceae | Unknown | M | I | H |
| Stemodia durantifolia (L.) Sw. | Lamiaceae | Ortega falsa | D | N | C |
| Stemodia durantifolia (L.) Scop. | Scrophulariaceae | Contrayerba | D | I | T |
| Stenotaphrum secundatum (Walter) O.K. | Poaceae | Pasto ancho | M | I | H |
| Stuckenia pectinata (L.) Börner | Potamogetonaceae | Huiro | M | N | Cr |
| Teline mospessulana (L.) K. Koch | Fabaceae | Lluvia de oro | D | I | F |
| Tetragonia spinosa Muñoz | Aizoaceae | Perllila | D | N | C |
| Tetragonia maritima Barn. | Aizoaceae | Aguanosa | D | N | C |
| Trifolium angustifolium L. | Fabaceae | Trébol hoja angosta | D | I | T |
| Trifolium dubium Sibth. | Fabaceae | Trébol enano | D | I | T |
| Trifolium pratense L. | Fabaceae | Trébol rosado | D | I | C |
| Trifolium repens L. | Fabaceae | Trébol blanco | D | I | H |
| Triglochin maritima L. | Juncaginaceae | Hierba de la paloma | M | N | H |
| Tweedia birostrata (Hook. & Arn.) Hook. & Arn. | Asclepiadaceae | Saumerio | D | N | C |
| Typha domingensis Pers. | Typhaceae | Vatro chico | M | I | Cr |
| Ugni molinae Turcz. | Myrtaceae | Murtilla | D | N | F |
| Uncinia phleoides (Cav.) Pers. | Cyperaceae | Clin-Clin | M | N | H |
| Verbascum thapsus L. | Scrophulariaceae | Hierba el paño | D | I | T |
| Verbena corymbosa Ruiz & Pav. | Verbenaceae | verbenas | D | N | H |
| Veronica anagallis-aguatica L. | Scrophulariaceae | Nomeolvides | D | I | Cr |
| Vulpia bromoides (L.) S.F. Gray | Poaceae | Vulpia | M | I | T |
| Xanthium cavanillesii Schouw. ex Didr. | Asteraceae | Abrojo | D | I | T |
| Xanthium spinosum L. | Asteraceae | Clonqui | D | I | T |