An edaphological, morphological and climatic classification of freshwater forested wetlands from Chile

Una clasificación edafológica, morfológica y climática de humedales boscosos de agua dulce de Chile

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ABSTRACT

Wetlands of the same kind can present considerable difference in relation to a series of environmental variables that influence on the physicochemical properties and on the biological communities sustained, natural variability scarcely considered in comparative studies. The aim of this work was to provide a first approach to the edaphological, morphological and climatic classification of the forested wetlands from central Chile, unique environments for the conservation of an interesting floraland faunal diversity. 18 wetlands were classified in the Araucanía Region, by means of the B classification procedure by the European Union Water Framework Directive. 21 variables at basin scale were used. Four ecotypes were obtained, which were characterized mainly by microclimates and soil types, though were also relevant morphological variables such as slope, slope of the wetlands, and the basins towards they drain (Wilks’s Lambda < 0.193, F > 3.84). Ecotypes determined were defined by: 1) convergence of moderate marine, warm and Mediterranean climates with silty clay loam soil and high slopes, 2) moderate marine climate with silty loam soil and high slopes, 3) Cold Mediterranean climate with silty loam soil and low slopes and 4) Moderate marine climate, silty clay loam soil and high slope. Classification is in agreement with in situ observations. Nevertheless, it must be validated by both limnological and biological approaches.

KEYWORDS: Forested wetlands, freshwater, macro-variables, basin, classification, ecotypes, Chile.

RESUMEN

Humedales del mismo tipo pueden presentar diferencias considerables en relación a una serie de variables ambientales que influyen en las propiedades fisicoquímicas y a su vez en las comunidades biológicas que sustentan. Sin embargo, en estudios comparativos, esta variabilidad natural es generalmente poco considerada. El objetivo de este trabajo fue realizar una primera aproximación de una clasificación edafológica, morfológica y climática de los humedales boscosos de la zona central de Chile, ecosistemas únicos para la conservación de una interesante diversidad de flora y fauna. Se clasificaron 18 humedales presentes en la región de la Araucanía, mediante el procedimiento de clasificación B de la Directiva Marco del Agua de la Unión Europea, utilizando 21 variables a escala de cuenca. Se obtuvieron cuatro ecotipos, caracterizados principalmente por el microclima y tipo de suelo, aunque también fueron relevantes variables morfológicas, como la pendiente y la superficie de sus cuencas (Lambda de Wilks < 0.193, F > 3.84). Los ecotipos determinados estuvieron definidos por: 1) Convergencia de climas marino fresco, cálido y mediterráneo frío, con suelo franco arcillo limoso y pendientes altas, 2) Clima marino fresco con suelo franco limoso y pendientes altas, 3) Clima mediterráneo frío con suelo franco limosos y pendientes bajas y 4) Clima marino fresco, suelo franco arcillo limoso y pendiente alta. La clasificación debe ser posteriormente validada mediante observaciones in situ de variables limnológicas y biológicas.

PALABRAS CLAVE: Humedales boscosos, agua dulce, macro-variables, cuenca, clasificación, ecotipos, Chile.
INTRODUCTION

Classification of superficial water bodies is a previous and relevant step for all environmental evaluation methods (Resh et al. 1995, Reynoldson et al. 1997). It comes from the necessity of obtaining information about its state and functioning (Bonada et al. 2002, Tiner 2009) in order to carry out proper actions of both conservation and management (Verdonschot & Nijboer 2004).

Wetland classification systems have been developed in the world for over more than three decades and they correspond mainly to qualitative methods (e.g. Cowardin et al. 1979, Brinson 1993, Warner & Rubec 1997, Dini et al. 1998, Ramírez et al. 2002, Clausen et al. 2006, Sieben et al. 2016) based on intrinsic characteristics of these water bodies, such as water regime, depth, vegetation and kind of substrate (Adamus et al. 1991, Adamus 1992, Leibowitz et al. 1991, Innis et al. 2000). Despite the development of this kind of classification, diversity of wetlands only has allowed the general grouping of different types of wetlands (e.g. cushion bogs, marsh vegetation or forest; Squeo et al. 2006, Valdovinos 2006, Correa-Araneda et al. 2011) which, in turn can intrinsically present considerable differences because of the edaphological, morphological and climatic variability (Munné & Prat 1999). In comparative studies, this variability is generally not very considered despite the important influence that macro-spatial variables can have over physicochemical properties of the water (Allan & Castillo 2007) and on the patterns of the biological communities of these water bodies. A method that diminishes or isolates such variability from the rest of the components, is the delimitation or identification of ecotypes (EC 2000, Marchant et al. 2000, Bonada et al. 2002, Sánchez-Montoya et al. 2007, Traversettì & Scalici 2014), because this kind of classifications are intended to the identification of reference sites (scarcely perturbed) for every grouping or ecotype, with its inherent biological communities. This would allow establishing real and comparative relations among communities present in the different kinds of wetlands, making easier the determination of its ecological state on the basis of a more reliable and precise way (Gerritsen et al. 2000).

At world-wide level, the greatest advances on this issue have been performed because of the Water Framework Directive (WFD) developed by the European Commission more than fifteen years ago (EC 2000), which presents a number of applications, mainly in Europe (e.g. Bonada et al. 2002; Verdonschot & Nijboer 2004, Moog et al. 2004, Grindlay et al. 2010, Sánchez-Montoya et al. 2012, Ruiz-García & Ferreras-Romero 2015). However, reality in Chile shows scarce experience on this issue and at wetland level there are only general classifications adjusted to international models (e.g. Ramírez et al. 2002) and others developed by national agencies encouraged by the frame of the national Strategy for Conservation and Rational Usage of Wetlands (CONAMA 2005), but these are not based on the previously mentioned method. Because of the formerly mentioned, the aim of the current study was delivering a first approach to the edaphological, morphological and climatic classification of ecotypes of forested wetlands, due to their condition of unique environments for the conservation of an interesting floral and faunal diversity in the country.

MATERIAL AND METHODS

STUDY AREA

The area under study is located in Southern Chile, specifically in the Araucanía Region (37° - 40° S). Preponderant climate in this zone is of wet-Mediterranean type and it is characterized by dry summers and wet winters with annual precipitations in a range of 1200 mm to 1600 mm. Summer temperatures fluctuate between 14-23°C and winter temperatures, between 7-13°C (Paskoff 1973, Di Castri & Hajek 1976, Barry & Chorley 1985, Luebert & Pliscoff 2006).

Identification and selection of sampling units was carried out by means of a cartographic predictive model consisting in the superposition of geographic information layers on main attributes respect to the use of soil (flooded meadows, native scrubs) and surface water network (streams and rivers). As potential wetlands those points where all three already mentioned elements converged were considered. Then, they were in situ corroborated, allowing both identification and georeferentiation of 18 sites (Fig. 1). Previously georeferentiated wetlands were delimited by interpretation of aerial photographs (1:20.000) supported by the Chilean Vegetation Census (CONAF-CONAMA-BIRF 2007). Later, a Digital Elevation Model (DEM) based on topographic maps (1:25.000) from the Geographic Military Institute of Chile (IGM 1968) updated to 2000 was used. Thus, delimitation and characterization of the wetlands and their basins was performed (Table 1). All analyses were carried out by means of the software ArcGIS 9.3.

VARIABLES USED

Classification of wetlands was carried out by means of the B classification procedure, from the Water Framework Directive by the European Union (EC 2000). In order to achieve this, 21 variables at basin scale were used, grouped in edaphological, morphological and climatic, where those considered as compulsory were included, some optional variables according to such procedure, as well as other added ones, considering the unique features of the kind of ecosystem studied (Table 1, Table 2).
**TABLE 1.** Characterization of wetlands studied based on the variables considered for classification. Elev. = Elevation (m.a.s.l.); Lat. = Latitude (UTM); Long. = Longitude (UTM); BS = Basin surface (Ha); WS = Wetland surface (Ha); BCI = Basin compactness index; Soil texture (%) (SL = Silt loam, FSL = Fine sandy loam, SCL = Silty clay loam, CL = Clay, REC = Recently); AZ = Agro-climatic zone (CDL = Coastal Dry Land, CV = Central Valley); MC = Micro-clime; (CM = Cold Mediterranean, FM = Fresh marine, WM = Warm marine); AT = Annual Mean Temperature (°C); AP = Annual precipitation (mm).

| Elev. | Slope | Lat. | Long. | BS  | WS  | BCI | BS/WS | SL  | FSL | SCL | CL  | REC | AZ   | MC   | AT  | Isohyet | AP     |
|-------|-------|------|-------|-----|-----|-----|-------|-----|-----|-----|-----|-----|------|------|-----|---------|--------|
| Vergel | 182   | 1.8  | 733692| 5728936| 2840 | 138 | 1.6  | 20.6 | 25  | 39  | 36  | 0    | 0    | CV   | CM   | 12.2 | 1600   | 1878.8 |
| Quillem | 239   | 0.8  | 724435| 5739027| 3527 | 603 | 1.7  | 5.8  | 0   | 0   | 100 | 0    | 0    | CV   | CM   | 10.5 | 1600   | 1659.9 |
| Pumalal | 158   | 5.9  | 715992| 5724545| 3344 | 192 | 1.3  | 17.4 | 0   | 0   | 100 | 0    | 0    | CV   | CM   | 12.2 | 1600   | 1191.4 |
| Quepe  | 95    | 0.3  | 706733| 5694579| 642  | 346 | 1.5  | 1.9  | 46  | 0   | 54  | 0    | 0    | CV   | CM   | 12.2 | 1600   | 1576.3 |
| Catrimalal | 111   | 2.6  | 706032| 5714338| 902  | 587 | 1.2  | 1.5  | 99  | 0   | 0   | 0    | 1    | CV   | CM   | 12.2 | 1600   | 1191.4 |
| Petrenco | 94    | 2.7  | 703296| 5675733| 3630 | 269 | 1.2  | 13.5 | 100 | 0   | 0   | 0    | 0    | CV   | FM   | 12.2 | 2000   | 1576.3 |
| Pelales | 78    | 0.1  | 697862| 5694661| 951  | 161 | 1.3  | 5.9  | 0   | 13  | 87  | 0    | 0    | CV   | CM   | 12.2 | 1600   | 1576.3 |
| Freire  | 59    | 0.3  | 696145| 5686174| 814  | 65  | 1.7  | 12.5 | 55  | 0   | 0   | 34   | 12   | CV   | CM   | 11.9 | 1600   | 1576.3 |
| Botacura | 70    | 10.2 | 694329| 5668948| 4431 | 123 | 1.4  | 36   | 100 | 0   | 0   | 0    | 0    | CV   | FM   | 11.7 | 2000   | 2163.3 |
| Botacura B. | 62    | 5.6  | 693414| 5670662| 2654 | 247 | 1.2  | 10.7 | 50  | 0   | 50  | 0    | 0    | CV   | FM   | 11.7 | 2000   | 2163.3 |
| Labranza | 60    | 0.7  | 692904| 5707675| 1434 | 241 | 1.6  | 1.2  | 7   | 0   | 93  | 0    | 0    | CV   | CM   | 12.2 | 1600   | 1191.4 |
| Santa Rosa | 51    | 8.9  | 689305| 5663514| 2761 | 202 | 1.2  | 13.7 | 46  | 0   | 54  | 0    | 0    | CV   | FM   | 11.7 | 2000   | 2163.3 |
| Los Puentes | 65    | 11.5 | 686512| 5655648| 10584| 331 | 1.4  | 31.9 | 100 | 0   | 0   | 0    | 0    | CV   | FM   | 11.7 | 2000   | 2163.3 |
| Mahuidanche | 68    | 10.5 | 684420| 5662796| 2195 | 14  | 1.2  | 155.2| 0   | 0   | 0   | 100  | 0    | CV   | FM   | 11.7 | 2000   | 2163.3 |
| Rehuelhue | 36    | 0.1  | 676257| 5686245| 5364 | 1210| 1.5  | 4.4  | 100 | 0   | 0   | 0    | 0    | CV   | CM   | 11.9 | 1200   | 1255  |
| San Roque | 0     | 11.6 | 676197| 5660435| 13487| 82  | 1.4  | 164  | 100 | 0   | 0   | 0    | 0    | CDL  | FM   | 11.9 | 1600   | 1853  |
| Nohualhue | 26    | 7    | 666834| 5685390| 2778 | 107 | 1.3  | 26   | 100 | 0   | 0   | 0    | 0    | CV   | CM   | 11.9 | 1200   | 1255  |
| Toltén   | -3    | 0.1  | 658293| 5662739| 1701 | 62  | 1.4  | 27.5 | 48  | 0   | 52  | 0    | 0    | CDL  | WM   | 11.9 | 1600   | 1853  |
STATISTICAL ANALYSES

In order to delimitate the ecotypes, the correlation level among variables previously standardized was determined by means of the Sparman’s Statistics Rho, discarding those variables with significant correlations ($r > 0.8; p < 0.05$). From these selected variables a principal components analysis (PCA) was carried out and the new axes obtained allowed the application of the K-means non-hierarchical grouping method in order to obtain ecotypes, a priori proving the formation of three to six ecotypes in relation to the maximum differences expected among the selected sites. Later, the Wilks’s Lambda discriminant analysis was used to identify the most significant variables ($P < 0.05$) among the ecotypes selected with the K-means statistic, considering the ecotypes that presented values close or equal to zero (different ecotypes), and discarding those ecotypes that presented values close or equal to one (equal ecotypes). However, the selection of a variable does not imply to be considered as discriminant, so the statistic $F$ associated to the Wilks’s Lambda distribution was used, and the values of $F > 3.84$ those that were considered as discriminant. Once statistically significant variables were known, the grouping that better explained the sampling sites in the environmental matrix studied was selected.

From the axes obtained of the analyses of the principal components, an Euclidian distance matrix was elaborated, which allowed to perform a parametric multidimensional scaling analysis (NMDS; Clarke & Green 1988), in order to visualize graphically (three-dimensions) the relation among the previously defined groups. From the very same distance matrix, one way ANOSIM test was carried out (Clarke & Warwick 2001) in order to determine if such groups statistically differed from each other, using the ecotype as factor. All statistic calculations were performed by means of the software SPSS 17.0 (SPSS Inc. Chicago, Illinois) y Primer v.6 (Clarke & Gorley 2005).

RESULTS

The wetlands were located mainly in the central valley zone, between -3 (Toltén) and 239 (Quillen) m.a.s.l., with slopes from 0.1º (Toltén) to 11.6º (San Roque) and surface between 14.1 (Mahuidanche) y 1209.1 (Rehuelhue) Has. The soil type of the basins was largely silty loam and silty clay loam. The prevailing micro-climes were cold Mediterranean and fresh marine, with temperatures between 10.5 and 12.2ºC and precipitations between 1255 and 2163.3 (mm year) (Table 1).

After the series of the already determined groupings (3 to 6 groups) was obtained, that one formed by four ecotypes was selected, because it reflected better the spatial patterns of sampling sites. A similar grouping was obtained through the NMDS analysis, where the exploratory analysis indicates the formation of four groups which present highly significant differences (ANOSIM $R$ global = 5.02; $p = 0.004$) (Fig. 2). Ecotypes were characterized mainly for microclimate and kind of soil, though the slope morphological variable was also relevant (Wilks’s Lambda < 0.193; $F > 3.84$: Table 3).

Graphic representation of the variables represented as discriminant allowed to characterize every one of the ecotypes (Fig. 3). About this, ecotype 1 formed by four wetlands was characterized by a convergence of climates (marine moderate, warm and Mediterranean cold), with silty clay loam soil and low slopes (0 - 5 %). Ecotype 2 includes San Roque and Los Puentes wetlands, it has moderate marine climate, with silty clay loam soil and high slopes (9 - 12%). Ecotype 3 that grouped most of the wetlands (10) has cold Mediterranean climate, with silty loam soil and high slopes (9 - 12%). Ecotype 4, with two wetlands (Mahuidanche and Santa Rosa) presented similar features to ecotype 2 and it was characterized by the same climate (marine moderate) and slopes (high), but it was different in the kind of silty clay loam soil (Table 4).
**TABLE 2.** List of descriptor variables used for classification of Chilean forested wetlands and its comparison with the variables established for the B Methodology of the Water Framework Directive. A = obligatory variables according to WDF; B = alternative variables according to WFD; C = new variables included in this classification.

| Type                  | Chilean Forested Wetlands | Water Framework Directive | Unit |
|-----------------------|---------------------------|----------------------------|------|
| Morphologic           | Morphologic               | Morphologic               |      |
| Altitude              | Altitude                  | Altitude                  | Meters A |
| Slope                 | Water mean slope          | %                          | B    |
| Latitude              | Latitude                  | UTM                        | A    |
| Longitude             | Longitude                 | UTM                        | A    |
| Basin surface         | -                         | Hectares                   | C    |
| Wetland surface       | -                         | Hectares                   | C    |
| Basin compactness index| Form and configuration of riverbed | -                          | B    |
| Basin surface / Wetland surface | -                  | Hectares                   | C    |
| - Form of the valley  | -                         | -                          | B    |
| - Water medium depth  | Meters                    | B                          |
| - Size                | Meters                    | A                          |
| - Distance from river origin | Meters                | -                          | B    |
| Edaphologic           | Type of soil              | -                          | C    |
| - Substrate mean composition | -                       | -                          | B    |
| Climatic              | Agro-climatic zone,       | -                          | C    |
| Microclimates         | -                         | -                          | C    |
| - Oscillation of air temperatures | °C                     | B                          |
| Temperature           | Mean air temperature      | °C                        | B    |
| Precipitations        | Precipitations            | Millimetres                | B    |
| Isohyets              | -                         | Millimetres                | C    |
| Geologic              | Geology                   | -                          | A    |
| Hydrologic            | Flow energy               | -                          | B    |
| - Mean water depth    | Meters                    | B                          |
| - Flow rate category  | m³/s                      | B                          |
| - Solid transportation| -                         | B                          |
| - Acid neutralization capacity | -                           | -                          | B    |
| - Chlorides           | Chlorides                 | mgL                        | B    |

**TABLE 3.** Discriminant variables according to statistic F associated to the Wilks’s Lambda distribution (F > 3.84).

| Step | Variable       | Tolerance | F to Remove | Wilks’s Lambda |
|------|----------------|-----------|-------------|----------------|
| 1    | Morphological  | 1.00      | 42.25       | -              |
| 2    | Morphological  | 0.89      | 36.31       | 0.45           |
|      | Kind of soil   | 0.89      | 5.41        | 0.11           |
| 3    | Morphological  | 0.70      | 28.71       | 0.19           |
|      | Kind of soil   | 0.80      | 5.53        | 0.06           |
|      | Microclimate   | 0.64      | 4.64        | 0.05           |
FIGURE 2: Three-dimensional ordering graph of the non-parametric multidimensional scaling (N-MDS), based on axes obtained from the principal component analysis of variables at basin scale. ● = Ecotype 1, ♦ = Ecotype 2, □ = Ecotype 3, ▲ = Ecotype 4; stress 3D = 0.03.

FIGURA 2: Gráfico de ordenamiento en 3-dimenciones del escalamiento multidimensional no-paramétrico (N-MDS), basado en los ejes obtenidos del análisis de componentes principales de las variables a escala de cuenca. ● = Ecotipo 1, ♦ = Ecotipo 2, □ = Ecotipo 3, ▲ = Ecotipo 4; estrés 3D = 0.03.

FIGURE 3: Values graph of the variables identified as discriminant for every ecotype.

FIGURA 3: Gráfico de los valores de las variables identificadas como discriminantes para todos los ecotipos.
DISCUSSION

Although the reduction in the natural variability of the aquatic ecosystems by means of the ecotype delimitation method has been recognised as a critical stage and previous to the evaluation of its ecologic state, its applications are recent and confined only to Europe and North America (e.g. Chovarec et al. 2000, Bonada et al. 2002, Verdonschot & Nijboer 2004, Moog et al. 2004, Dodkins et al. 2005, Grindlay et al. 2010). DMA method for identification of typologies of aquatic ecosystems uses the combination of environmental macro-describers (e.g. geology, climate), though new variables as a function of the local characteristics of water bodies and the availability of information can be added (Verdonschot & Nijboer 2004). In the current study, new variables such as basin surface, wetland surface, agro-climatic zone were included (Table 2), thus performing an adaptation of the original method to the reality of the studied ecosystem. This is due to the fact that originally such method was conceived for classification of fluvial ecosystems and presents variables measurable only in this kind of system. However, results proved to be a good approach that can be used for the management of these water bodies.

In the zone under study a wet Mediterranean climate predominates, with dry summers and temperatures ranging 14-23 °C and wet winters, with temperatures between 7-13 °C (Paskoff 1973, Di Castri & Hajek 1976). At local level, a set of microclimates derived of a high geographic variability is presented through both latitudinal and longitudinal axes. These microclimates prevailed as descriptor variables above macroclimatic variables (temperature and precipitation) and can be relevant at the time of validating results in relation to environmental variables (physicochemical) and biologic components. At spatial mid-scale, the first parameters of the soil differ from macroclimates given the velocity by which changes are produced affecting, for example, to the drastic variation of the temperature in the first centimetres above the soil (Rosenberg et al. 1983). These are the primary conditioners to the organisms inhabiting the studied ecosystems. On the matter, density of canopy can be a conditioner feature for regulating the variables, over the incidence of outer energy at macroclimate level.

Moderate marine microclimate, determinant to the ecotypes 2 and 4 was characterized by presenting frequent rainfall, with fresh polar air masses that provide abundant clouding and well distributed precipitation, with a maximum in winter (Barry & Chorley 1985). On the other side, cold Mediterranean climate that defined ecotype 3 presents rainy winters and dry summers which is a consequence of the seasonal variation of the conditions that originate marine climates of the South American western coast. During winter maritime polar air masses predominate along with low pressures and abundant precipitations, whereas during summer maritime tropical air masses predominate, producing important droughts (Barry & Chorley 1985). This microclimate is similar to the climate that defines the Mediterranean macro-zone (32-41° S; Di Castri 1981, Strahler & Strahler 1989), but with lower temperatures both in winter and summer. A relevant aspect to be considered is that ecotype 1 presents a mixture of 3 microclimates which indicates that variables “type of soil” and “slope” are the real descriptor of this grouping. On this matter, the kind of soil was also a relevant factor for the classification of the forested wetlands, by presenting silty loam textures (ecotypes 2 and 3). These were characterized by having a reduced amount of clay (0-25%), an intermediate amount of fine sand particles (20-50 %), whereas more than half of the particles were silt (70-90 %) (USDA 2009). This implies a permeability condition and moderate infiltration velocity in a range of 10⁻³-10 m/day (Gregory & Walling 1985, USDA 2009). On the other side, ecotypes 1 and 4 (silty clay loam soil) present a greater clay percentage in their soils (30 40 %), decreasing their permeability by increasing the clay content (Gavande 1972), causing a decrease in retentation and availability of superficial water (Acevedo 2003), as a result of the low infiltration velocity of the soils (Gregory & Walling 1985, USDA 2009). However, this accumulates in depressions, thus forming the permanent forested wetlands.

In relation to slopes, these presented intermediate values, segregating wetlands in groups of low and high slopes. Thus, ecotypes 1 and 3 are located in flat terrains, whereas 2 and 4 are placed in a moderately inclined relief. The implications of these two kinds of slopes on the wetland features are related mainly on the transport of sediments.
and dragging (Strahler & Strahler 1989). On the other side, in low zones or flat lands, it is expected that in summer time, when there is a lower water contribution coming from precipitation, a stable availability or water volume is presented (Fuentes-Junco 2004). Therefore, it is possible that most of the wetlands classified as ecotypes 1 and 3, present permanent water regimes, with a decrease in water volume in summer time, though keeping water availability during the whole year, which is in agreement with what was reported by Correa-Araneda et al. (2012, 2014a, b) for the wetlands of Quepe, Petrenco and Nohualhue but not for Pumalal, Catrimalal and El Vergel. This can be associated to the high degree of intervention of their basins, as well as the ecosystem.

The opposite to the case previously described takes place in the zones with higher slopes (ecotypes 2 and 4), where water deficit periods would occur (Fuentes-Junco 2004), because such slopes are characterized by presenting a greater flows and the water resource tends to flow faster out of the basin, favouring the existence of wetlands with shorter water periods (4-8 months; Ramírez et al. 1995) and also influenced by a decrease of precipitations during summer time. Nevertheless, this period can also increase or decrease its duration, in a direct relation with physical characteristics of the basin (Gregory & Walling 1985, Gavande 1972, Acevedo 2003, USDA 2009. Correa-Araneda et al. 2011).

Even though the present classification agrees in some way with observations carried out in situ, its biological validation becomes fundamental (Sandin & Johnson 2000, Sánchez-Montoya et al. 2007), what it is highly complex because the limnological information of these ecosystems is poor and limited to only a few wetlands, especially respect to aquatic communities commonly used for this purpose (e.g. benthic macroinvertebrates). However, recently there have been increased efforts to deepen the knowledge of the aquatic communities of these important ecosystems (e.g. Correa-Araneda et al. 2012, 2014a, b).

Moreover, this lack of knowledge avoids the final calibration of the methods created for the management of water resources. The previous issue is a pending task that it has to be solved by specialists mainly if in recent times several intentions in order to carry out actions intended to the proper management of the Chilean freshwater ecosystems have raised.

Generally, protection of these systems occurs only when there is a legislative support. On this matter, the current Chilean normative only allows regulating the intervention of water bodies by means of the unloading of liquid contaminants, establishing the characteristics of industrial effluents (DS N°90 2000). Despite the fact that this normative is intended to prevent contamination of water bodies by means of controlling contaminants associated to liquid residues, this is not completely effective, because it does not considers the effect that these contaminants can have on the aquatic biota. Before this, and as away to counteract these deficiences, the elaboration ad implementation of the Secondary Norms of Water Quality is under revision. This norm are initially designed (2004) for large eco-regions and currently with an approach on fluvial or lacustrine basins and with low clarity on wetlands in the planning. Moreover, this norm does not consider the micro-spatial variability, what can lead to errors on water resources management (Abell et al. 2008), what it would happen if ecotype delimitation was considered as an initial stage. This implies the utilization of variables at local level and, therefore, a more accurate classification of the aquatic systems (Gerritsen et al. 2000).

Given the previously stated, it is expected that in later stages of the current study, aquatic communities present in wetlands can be identified. This would be in agreement with the already established ecotypes. At the same time, the degree of intervention of these aquatic ecosystems must be determined, in order to establish possible reference sites for every ecotype and thus, contributing to a more accurate and necessary management of the water bodies.

ACKNOWLEDGMENTS

This study was financed by CONAF 035-2010 and FONDAP CRHIAM 1513001 projects. Authors would also want to thank Jonathan Urrutia, Marilyn Gonzalez, Pablo Pedreros and Maria Fernanda Aguayo for their assistance in field work and data analysis.

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Recibido: 08.04.15
Aceptado: 15.03.16