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Original article

Diversity patterns and composition of native and exotic floras in central Chile

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ABSTRACT

Floristic changes in the Mediterranean region of central Chile brought about by human impact appear to be shared with other climatic regions, although there is a notable absence of empirical studies and available quantitative evidence for the central Chile region. This study examines the cover, richness and composition of native and exotic plant species in a representative area of central Chile. Through floristic characterization of 33 sites sampled using 40 × 40 m plots distributed along transect on which the two farthest sites were separated by 50 km, the floristic richness and cover patterns, as well as the general land use characteristics were evaluated (native matorral, espinal, abandoned farming field, forest plantations, periurban sites, road sites, river bank, and burnt site). We recorded 327 species of plants; 213 species were native and 114 were exotic. The average number of species was heterogeneous in all sites, showing a greater relative native frequency in those sites with a lower level of anthropic intervention. Except for the matorral, the cover of exotic species was greater than that of native species. No relation was found between richness and cover in relation to the different types of land use. The relationship between cover of native and exotic was negative, although for richness did not show relationship. Results show that the exotic species are limited by resources, although they have not completely displaced the native species. The native and exotic floras respond to different spatial distribution patterns, so their presence makes it possible to establish two facts rarely quantified in central Chile: first, that the exotic flora replaces (but does not necessarily displace) the native flora, and second, that at the same time, because of its greater geographic ubiquity and the abundance levels that it achieves, it contributes to the taxonomic and physiognomic homogenization of central Chile.

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1. Introduction

The world's Mediterranean-type ecosystems are characterized by presenting high levels of floristic richness (Davis et al., 1994). It is estimated that nearly 20% of the world's flora is found in the five Mediterranean-type regions, which together cover less than 5% of Earth's surface area (Cowling et al., 1996). Various ecological and evolutionary factors have been suggested to explain this diversity (di Castri, 1981; Arroyo et al., 2000), which is important not only because of its richness, but also because of its high level of endemism (Myers et al., 2000).

In spite of this importance, Mediterranean-type ecosystems have undergone substantial changes in their structure and ecosystemic functions as a consequence of human impact (Rundel, 1998). At present these regions support a large and increasing proportion of the world's human population, with equally increasing demands for space and natural resources (Rundel, 1998; Sala et al., 2000). As a consequence of this the biota in these ecosystems is seriously threatened; hence they are considered hotspot regions on the global scale (Myers et al., 2000).

The modification of diversity in the Mediterranean-type ecosystems is manifested in all biological groups and under various temporal and spatial scales (Mooney et al., 1989). Of particular importance are the changes in floristic composition because this involves conspicuous modifications in the physiognomy, structure and function of the ecosystems (Randall et al., 1998). Modifications of the flora comprise two mechanisms (McKinney and Lockwood, 1999): extinction or extirpation of species, and the concomitant increase of the number of species introduced by humans (Groves and di Castri, 1991; Gaertner et al., 2009). Therefore, the balance between both processes is one of the main agents that determine

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the floristic future of these ecosystems, whose magnitude and trends have yet to be established empirically.

The Mediterranean-type area of central Chile (31–38°S) corresponds to one of the world's five Mediterranean ecosystem regions (Cody and Mooney, 1978). This region contains a floristic richness of 2395 native species, of which 50% are endemic (Arroyo et al., 1995; Arroyo and Cavieres, 1997). Moreover, there are 507 exotic species that represent 18% of total flora (Arroyo et al., 2000). This proportion is relatively low compared to California, its closest climatic analogue, even standardizing that number per unit area (Arroyo et al., 2000; Jiménez et al., 2008). However, regardless of this regional scenario, the processes and mechanisms that determine the diversity of native and exotic species and the patterns that characterize their distribution are aspects that are little understood in central Chile (Figueroa et al., 2004). In this line, only three comparative studies with California have made some progress. Firstly, Arroyo et al. (2000) analyzed the patterns of richness of weed species from a political-administrative standpoint. They found that the number of weed species was significantly associated with the type of land use, particularly with urban areas and roads. Later, Sax (2002), in a comparative study of xerophytic bushy communities in the arid portion of Mediterranean Chile, reported that the diversity of exotic species correlated positively with that of native species. Finally, Jiménez et al. (2008) compared the taxonomic composition of the exotic flora of Chile and California, finding that in spite of the compositional differences between the two regions, in the presence of human perturbation both floras tended to increase in similarity. The latter authors suggested that due to the process of globalization and the increase of anthropic perturbations, the regional floras may tend to become homogenized.

Although many of the floristic changes in the Mediterranean region of central Chile appear to be shared with other climatic regions (i.e. Randall et al., 1998; Loreau et al., 2001; Western, 2001; Gritti et al., 2006; Manor et al., 2008), there is a notable absence of empirical studies and quantitative evidence in this region. In the present study we characterize the diversity, richness and compositional patterns of the vascular flora in a representative area of the Mediterranean region of central Chile. Distinguishing between native and exotic floristic components, we evaluated at the landscape level, their spatial distribution, richness, and coverage patterns in relation to sites that differ in type of use and intensity of the anthropogenic perturbations. The questions that we will attempt to answer are (1) what is the relation between species richness and cover of native and exotic species? (2) what local scale factors can be associated with the richness and composition of exotic and native species? and (3) what sizes and trends in floristic change can be established for the Mediterranean region of central Chile?

2. Materials and methods

2.1. Study area

The study was conducted in the western sector of the Coastal Range in central Chile, over a distance of 50 km (around 33°S, see Fig. 1). In general terms, this area has regional importance due to its character as a floristic refuge during the last glaciations (Villagrán and Armesto, 2005). This geographic strip, below 1300 masl, has a Mediterranean-type climate characterized by an average annual precipitation of 435 mm and mean temperatures that reach 18.5 °C in the warmest month and 10.2 °C in the coldest month of the year (Luebert and Pliscoff, 2006).

In terms of vegetation, the formations originally recognized for our study area correspond to sclerophyllous coastal forest, characterized by the presence and dominance of woody species with sclerophyllous leaves (Gajardo, 1994). At present, the vegetation physiognomy of this area shows various structures and effects as a consequence of human intervention, among which we can recognize the so-called matorral, which corresponds to a successional remnant of the original native sclerophyllous forest; the espinal formations where most of the tree cover has been removed and replaced by the presence of espino (*Acacia caven*, a native Fabaceae) in the bushy-arboreal stratum and by exotic grasses in the herbaceous stratum; farming sites where intensive cultivation is associated with the presence of exotic weeds and native annuals; and forest plantations consisting mainly of the exotic species *Pinus radiata*, *Eucalyptus globulus*, and *Eucalyptus camaldulensis* (Teillier et al., 2010).

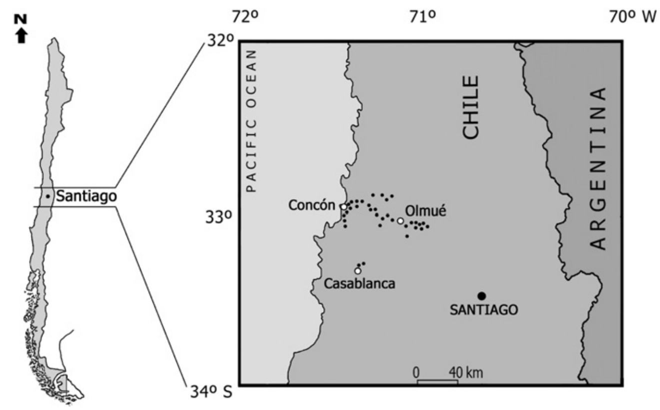

Fig. 1. Geographic location of the 33 sites sampled among Olmué, Concón and Casablanca, Valparaíso Province, Chile.

2.2. Sampling

Over a distance of 50 km we selected 33 sampling sites according to their accessibility (Fig. 1). In each of them a 40 × 40 m plot was made available, except in the sites located on the edge of roads ($N = 7$ sites), where plots of 2 m × 400 m were used.

At the center of each plot the geographic coordinates were determined by GPS (Garmin GPSmap 60CSx). Within each plot the vascular flora composition and cover of both the native and exotic components were established. The cover was established by means of the abundance-frequency scale of Braun-Blanquet (1979), and the values were then converted into percentages in accordance with the following equivalence: 5 = 87.5%; 4 = 62.5%; 3 = 37.5%; 2 = 17.5%; 1 = 5%; + = 0.1% (Braun-Blanquet, 1979).

The geographic distance was also determined for all the pairs of sample sites, as well as the current use of the soil in each plot. The geographic distance was set as the linear distance (km) between the plots using GPS, while the vegetation condition of land use of each site was inferred according to the following classification: matorral sites (MAT = 4 sites), espinal sites (ESP = 7 sites), abandoned crop sites (AGR = 6 sites), and forest plantations (FOR = 5 sites). Other sites were classified with respect to their location, periurban sites (URB = 2 sites), road edge sites (ROA = 7 sites), river bank (RIV = 1 site), and recent fire condition (BUR = 1 site burnt <3 years). Since fires are intentional in central Chile, the vegetation types had been burnt at some stages by human cause (Rundel, 1998). Nevertheless, in our study only 1 of the 33 sites showed evidence of having been affected by fires recently. The matorral corresponded to successional native forests with low trees and canopy cover above 70%. The espinal site was dominated by the woody Fabaceae *A. caven*, which presents a cover of <40.0%. The soil of the crops had been abandoned for at least three years and occasionally they presented shoots of woody plants. Forest

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