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Patterns of woody plant invasion in an Argentinean coastal grassland

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ABSTRACT

Coastal dune grasslands are fragile ecosystems that have historically been subjected to various types of uses and human activities. In Buenos Aires Province (Argentina), these areas are frequently afforested for urban and touristic development. The introduction and subsequent spread of exotic tree species is one of the main threats to conservation of natural grasslands as invasive trees strongly transform their structure and composition. The aim of this study was to identify patterns of woody plant invasion comparing plant communities and environmental variables between invaded and non-invaded areas surrounding the coastal village of Mar Azul, Argentina. Coastal grasslands in this area are being invaded by *Populus alba* (white poplar) and *Acacia longifolia* (coast wattle). The height of the saplings and the richness of the accompanying vegetation were evaluated in relation to the distance from the edge of the mature tree patches. Also, the cover, richness and diversity of all species in the invaded and non-invaded areas were measured, as well as soil pH, temperature and particle size. Negative correlations were found between the height of the saplings and distance to mature tree patches in all areas. The richness of the accompanying vegetation was negatively and positively correlated with the distance from the poplar and acacia area, respectively. The most abundant native species was *Cortaderia selloana*. Less cover, richness and diversity of native plant species and greater soil particle size were found in invaded areas, where the proportion of bare soil was higher. Also, a higher proportion of leaf litter in the invaded areas was registered. The results emphasize the invasive capacity of *P. alba* and *A. longifolia* advancing on the native communities and reducing their richness. Knowledge of the impact of invasive woody plants in coastal grasslands is important to design active management strategies for conservation purposes.

1. Introduction

Either intentionally or inadvertently, several species of different taxonomic and geographic origins have been relocated by man (Daehler, 2003), thus facilitating their dispersal across biogeographical barriers (D'Antonio and Vitousek, 1992; Vitousek et al., 1997; Figueroa et al., 2004). Once established in their new habitat, the exotic species can become widespread and modify the patterns of abundance and distribution of the native species (Figueroa et al., 2004). These invasive species may compete with native ones for space or food resources and affect ecosystems by altering (a) the resources available to other species, (b) the flow of energy or biomass across trophic levels, and/or (c) the natural disturbance regimes (Crooks, 2002).

Woody plant invasions are rapidly increasing in importance worldwide (see Richardson and Rejmánek, 2011 for a review). Transitions from grassland to woody systems can alter nitrogen dynamics (see Hellmann et al., 2011) and the balance of water and salt in the ecosystem (Jobbágy et al., 2008). Forests have higher transpiration capacity than grasslands because of their greater leaf surfaces, the roughness of the canopy and its deeper root systems. When higher transpiration occurs at the expense of consumption of groundwater, the establishment of trees on grasslands can cause salinization of soils and aquifers and jeopardize the sustainability of the forest system itself (Jobbágy et al., 2008). In such systems, most base cations are essential plant nutrients and play a key role balancing ecosystem acidity. Soil acidity in turn is a master control of soil fertility and affects many important biogeochemical processes, such as rock weathering and nitrification (Jobbágy and Jackson, 2003).

Natural grasslands are among the ecosystems that have been most disturbed by man (Hanna et al., 1995). The advance of exotic tree species as a result of invasion processes and direct plantation is one of the main threats to the conservation of natural grasslands

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and represents the introduction of a completely new life-form to the ecosystem (Richardson, 1998). Grasslands at the Argentinean Pampean plain have been subject of multiple transformations during the last two centuries, including exotic tree plantation and spread. Invasive trees have deeply transformed the structure and composition of native grasslands sometimes facilitating invasion by other exotic species (Zalba and Villamil, 2002). This process has reached a point where virtually all Pampean grasslands could no longer be restored naturally to their original state (Ghersa et al., 2002).

In Buenos Aires Province the last relicts of the Pampas's grasslands are restricted to habitats unsuitable for agriculture such as coastal dunes (Zalba and Villamil, 2002). Since the nineteenth century, these dune ecosystems have increasingly been subject of afforestation because of urbanization and coastal touristic development (Dadon, 2002). Afforestation has been carried out with the purposes of stabilizing dunes, reducing wind impacts, and increasing site attractiveness for tourists. Some of the most commonly used species for these purposes are *Acacia*, *Populus*, *Tamarix*, and *Pinus* and their dispersion now represents one of the main threats to dune conservation (Zalba and Villamil, 2002). Faggi and Dadon (2011) found that urbanization and touristic development are the main forces driving changes in plant composition along coastal dunes and beaches of Northern Argentina.

The objective of the present work was to evaluate patterns of dune grassland invasion by the woody exotic species *Populus alba* (white poplar) and *Acacia longifolia* (coast wattle), comparing plant communities and environmental variables in invaded and non-invaded areas.

2. Materials and methods

2.1. Study site and species

The study was conducted in a 5 km^2 coastal dune nearby Mar Azul village (37°20′S–57°02′W), Buenos Aires Province, Argentina (Fig. 1). The climate is humid temperate with a mean annual temperature of 14.0 °C. The average yearly precipitation is 930 mm mostly concentrated in winter (June to September). Soils are poorly developed and bear simple vegetal communities called "edaphic" since they are primarily controlled by soil, not climate (Cabrera, 1971).

The native plant community is a temperate grassland (Cabrera, 1971) now highly transformed (Vervoorst, 1967; Zalba and Villamil, 2002). There are stable populations of the invasive trees *P. alba* and *A. longifolia*, forming dense monospecific stands of large shrubs or small trees characteristic of an early stage of invasion. The distribution of poplar and coast wattle patches is quite heterogeneous. *P. alba* shows rapid growth and easy vegetative propagation by gemiferous roots. It also reproduces sexually but seedling survival and growth is highly dependent on soil moisture (González et al., 2010), which is low in sandy soils. *A. longifolia* is a leguminous N_2-fixing shrub that reaches up to 8 m height (Hellmann et al., 2011). It impacts hydrological and carbon cycling even in water-limited semi-arid ecosystems (Racher et al., 2011b) and has important effects on the catabolic diversity of soil microbial communities, which may have wider implications for nutrient cycling and ecosystem-level processes as well as the subsequently invasibility of the system (Marchante et al., 2008a). Acacias are often used to stabilize coastal dunes in different countries, subsequently spreading and invading considerable areas (Marchante et al., 2003; Fernández et al., 2006; Hellmann et al., 2011). *Populus* and *Acacia* are widespread woody invaders (five and thirty two invasive species respectively; Richardson and Rejmánek, 2011).

2.2. Plant surveys

Sampling was performed from spring 2009 to summer 2010. The study area was sub-divided into 4 strata: a) Mall: invaded by *P. alba*; b) Acacialaan: invaded by *Acacia longifolia*; c) Mixed: invaded by *P. alba* and *A. longifolia* and, d) Grassland: non-invaded grassland subdivided in 3 sub-strata; grassland adjacent to the Mall, the Acacialaan and the Mixed strata. Ten transects of variable length were located in each invaded area from the outer edge of the mature tree patches up to the last sapling or the presence of fences and paths. In the Grassland, thirty transects were distributed randomly, ten in each sub-stratum. Their length varied between 40 and 60 m, depending on the presence of paths. Sampling quadrats

Fig. 1. Study site, Mar Azul, Buenos Aires Province, Argentina.