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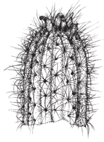

VEGETATION CHANGES ASSOCIATED TO COASTAL TOURIST URBANIZATIONS

CAMBIOS EN LA VEGETACIÓN ASOCIADOS A LA URBANIZACIÓN COSTERA TURÍSTICA

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RESUMEN

Este estudio señala procesos de homogeneización y diferenciación en la flora vascular de 18 localidades balnearias ubicadas en el extremo norte de la costa atlántica argentina. Las variables se estimaron a lo largo de un gradiente de uso de suelo y de actividades extendiéndose por la franja costera desde los centros urbanos hasta 10 km alejados del centro. Se realizaron 90 censos en 38 sitios de muestreo en los centros, a 2 km, 5 km y a 10 km del límite urbano. Comparamos similitud espacial y temporal entrelos sitios usando datos actuales e históricos.

En las áreas céntricas el número de especies actuales (114) duplica la riqueza de épocas previas al desarrollo turístico (40). Muchas especies inmigrantes han sido introducidas deliberadamente o se instalaron en forma espontánea proveniendo de comunidades vegetales vecinas y/o de áreas más distantes.

A lo largo del gradiente las plantas exóticas fueron más sensibles que las nativas para indicar algunos procesos. Se reconocieron dos "Eutrofización" and "Verde Urbano" como aquellos que más influyeron en la distribución y abundancia de las especies indicadoras.

Palabras clave: *Exóticas, Impacto humano, comunidades vegetales, homogeneización florística,turismo, dunas*

SUMMARY

This study shows evidences of plant homogenization and differentiation in the vascular flora of 18 beach resorts located along the northern end of the Argentinean Atlantic coast. Data were collected along a gradient of urban land-uses and activities, extending away from city centres along a line 10 km-long. Ninety plant surveys were carried out in 38 sampling sites at resort centres, 2 km, 5 km and 10 km from the urban edge. We compared spatial and temporal similarities among sites using current and historical data.

Our results showed that the current number of species (114) more than doubled the number recorded in pre-tourism times (40) at the resort centres. Many immigrant species were introduced – whether deliberately or not – from both neighbouring and far away plant communities. Clearly, exotics were more useful than natives to exposing some pre-existing drivers along the gradient. “Eutrophication” and “Urban green” were the two major driving forces affecting the distribution and abundance of indicators species.

Keywords: Exotics, anthropogenic impact, plant assemblages, floristic homogenization, tourism, dunes

INTRODUCTION

Evidences from many cities around the world show that urbanization is a drastic and widespread process that homogenises biota as communities become more similar to each other by the introduction and extinction of species (Wittig, 1996; Mc Kinney, 2005). This process is a big concern for the conservation of local biodiversity because it reduces it through the coupled effects of stimulating – intentionally or not – the extinction of rare species and the spread of exotic ones having a potentially high risk of invasiveness.

As a city spreads and its land is allotted to multiple and diverse uses, the new abiotic conditions thus created very likely impact on the status of thermal range and regime, water resources, and soil environment that can create habitability conditions favourable for the establishment and spread of immigrant species (Wittig *et al.*, 1985; Kowarik 2003). In parallel the habitat quality for natural vegetation decreases and many taxa, the most vulnerable and sensitive species, behave as “avoiders” of the new environmental conditions so that they decrease or disappear.

Changes in the plant composition affect attributes of the community such as structure, productivity, resilience, etc. Changes in competitive capability can modify species dominance and thereby the structure of the community. Resources "exploiters" species also called "synantropic" may increase their abundance because they benefit from the new environmental conditions. Some other species of flora and fauna that tolerate disturbances may become adapted to modified urban habitats and can remain in the perturbed environment as "adapter" species. (Mc Kinney 2006).

In beach resorts changes in land use resulting from urbanization and activities associated with tourism are usually recognised as a principal driving force behind biodiversity change (Lemauviel & Rozé, 2003). Coastal ecosystems are highly dynamic (Rust and Illenberg, 1996) and complex. Land use, watershed processes and biodiversity are often intricately linked to each other, and affected by several inputs (Stoms *et al.,* 2005). The stability of dunes is much imperilled when changes in land use like e.g. planting exotic trees and shrubs or recreational activities such as off-road driving, riding and hiking are carried out (Curr *et al.,* 2000; Levin & Ben Dor, 2004).

Coastal urbanization is regularly preceded by the stabilization of dunes with fast-growing plants, often exotics that strongly impact on local biodiversity (El-Keblawy & Ksiksi, 2005). Domestic gardening, urban forestry and green area stewardship are other important sources of increasing diversity in exotics. In a number of cases some of these species can grow spontaneously in remnant vegetated patches; occasionally some of them can become invasive.

The aim of this work is to study the anthropogenic impacts on the vegetation of several beaches located along a strip of Argentina's Atlantic coast. In particular we analyse temporal and spatial changes in floristic composition of fore dune vegetation due to urban development and human activities related to tourism.

We build upon the work of Dadon (1999, 2002), who postulated a model for the expansion of tourist uses of the coastal zones in the South Atlantic. In that model, tourism pressures are not confined to the boundaries of urbanised resorts; on the contrary, tourism-related activities extend gradually from urban to remote natural beaches. The spreading of beach uses and activities generates an impact gradient. Some of those are linked to a recreational urban beach – e.g. beaches with public services such as tents and parasols, dressing rooms, showers and restaurants –, others are linked to the dunes – e.g. camping and surfing – and others take place in both sectors but with different intensity and frequency – e.g. trekking, motorcycling, off-road driving, fishing, etc. –. Different impact intensities are expected along this gradient.

Mac Donnell and Pickett (1990), Mac Donnell *et al.* (1997) have applied the environmental gradient paradigm to urban environments. This approach has been very much used by many authors, linking flora and fauna to the intensity of urbanization (Blair, 1996; Jokimaki and Suhonen, 1993; Faggi *et al.,* 2006).

Differences in the composition of vegetation along the urban-natural dunes gradient would be caused by the advance of the tourist frontier; plant assemblages would reflect the growing pressures due to novel uses and activities. Consequently, some of the changes occurring in plant assemblages could be coupled to planting (afforestation, gardening), unintentional anthropocore and zoocore seed dispersal, trampling, vehicular traffic and eutrophication.

We focus our study on the vegetation change driven by the addition and/or loss of species to dunes derived from human activities and land use change along a strip of beach. Therefore, our work deals with the biotic homogenization effect described by Lockwood and Mc Kinney (2001), Mc Kinney (2005, 2006).

We hypothesise that because of tourist induced temporal and spatial changes

1. The vegetation of dunes fairly away from town centres will remain similar to the pristine original communities. In areas subjected to intermediate impact intensities plant assemblages will reflect transitional situations between city cores and rural areas.

2. Exotic species and extradune natives coming from neighbouring communities will displace many of the original native dune assemblages**.**

3. Plants indicating humidity are expected to be more frequent in urban areas because of irrigation coupled with the redistribution of run-off water by increased impervious surfaces.

MATERIAL AND METHOD

DESCRIPTION OF THE BEACH VEGETATION

The vegetation under study covers the dunes and comprises *Panicum* grasslands and forests. Woodlands are composed mainly by two exotic trees: *Acacia melanoxylon* and *Tamarix gallica*, which were planted for stabilizing the dunes. Historically the pristine dune vegetation was an open grassland composed of ca. 40 species, dominated by *Panicum racemosum,* and a relatively few alien plants. This grassland community was thoroughly described by Cabrera (1941); it can be considered the typical plant community previous to the advent of massive tourism to the beach. The intensification of human activities since the second half of the last century brought with it the deliberate introduction of specific plants for binding the dunes, creating woods for amenity uses and domestic gardening. These actions gradually decreased the population of sun-loving native dune species, and also facilitated the fortuitous proliferation of weeds and other immigrant species.

STUDY AREA

We surveyed 18 resorts along a strip of the Atlantic Ocean coast between 36º46' S; 56º49' W, and 38º59' S and 61º 15' W (Fig 1). The annual mean air temperature is about 14 ºC; mean precipitation ranges from 1,053 mm at the north of the strip (*Las Toninas*) to 830 mm at the south (*Necochea*), with maxima in spring and the end of summer. The mean wind velocity in the south (23.8 km/h) is about twice the north's (10.7 km/h). Tourism and recreation are the main activities of the costal strip, while in the neighbouring rural areas cattle raising and cereal cropping are the most frequent activities. Beaches have similar physiographic characteristics: they are dissipative, straight, wide, and long and composed of fine sand.

The names, population of the sampled resorts including the length of their beachfront are shown in Table 1. Most of the localities are small; only two (Necochea and Villa Gesell) have more than 20,000 inhabitants (2001 National Census).

Table 1. Population and length of the beachfront of the sampled town resorts
Tabla 1. Población y extensión del frente costero de las localidades estudiadas

Length of the beachfront					
	0 - 3 km		**3-6 km**		**+ 6 km**
Locality	**Population**	**Locality**	**Population**	**Locality**	**Population**
Aguas Verdes	459	*Las Toninas*	3,550	*Mar de Ajo*	16,573
Nueva Atlantis	80	*Claromecó*	696	*Sta. Teresita*	13,034
Costa del Este	6,916	*Monte Hermoso*	5,394	*San Bernardo*	6,966
Mar Azul	569			*Mar del Tuyú*6,	916
*Reta*1	05			*Pinamar*	9,810
*Cariló*1,	553			*Villa Gesell*	23,257
Pehuencó	674			*Necochea*	65,459
				Quequén	14,524

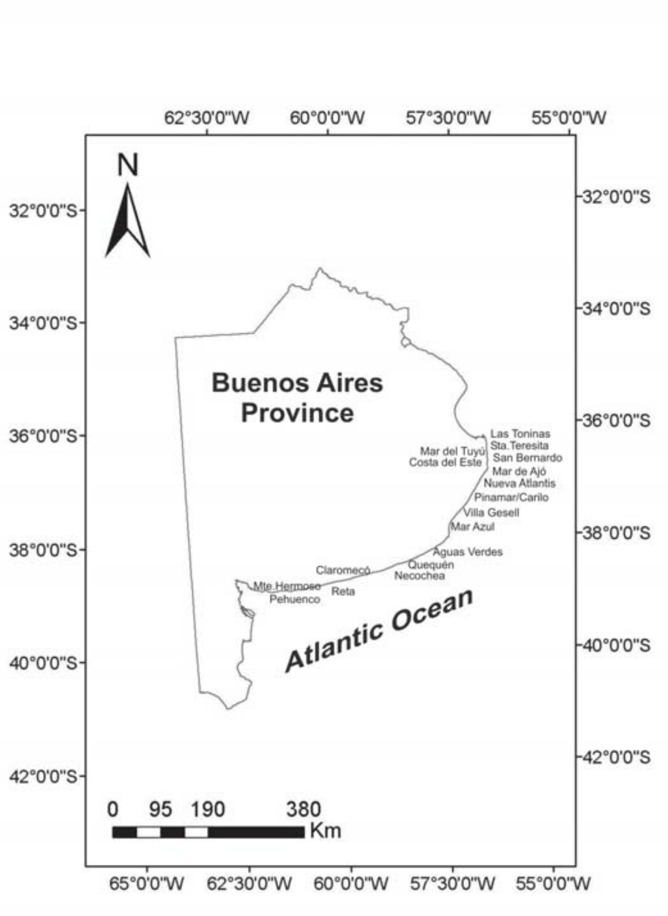

Figure 1. Study area
Figura 1. Área de estudio

SAMPLING DESIGN

At each beach resort sampling stations were selected along a transect extending from the town centre outwards. The transect origin was at: the urban centre (0 km), and the end was at the natural dune area (10 km away from the town edge). Two intermediate sampling stations were set at 2 km and 5 km away from the transect origin. In isolated resorts, the four sampling stations were easily set up, but some resorts tend to merge with each other. In such cases only stations at the urban centre could be surveyed and the data were used only for comparison among the urban beaches to avoid over sampling biases.

We made 90 inventories in 38 sampling sites. In each sampling station following indicators regarding geophysical, landscape, vegetation, uses and activities features have been registered:

Table 2. Geophysical, landscape, vegetation, uses and activities variables collected for each sampling station

Tabla 2. Variables geofísicas, paisajísticas, de vegetación, uso y actividades colectadas en cada sitio de muestreo

Geophysical features	**Type of variable**
Presence of cliffs, berms, restinga, dunes, type of slope, lotic and lentic water bodies	binary
Landscape features:	
Middle cover of dunes; of forest and of herbs patches.	quantitative (%)
Vegetation features	
Ground-cover of herbs, trees, natives, exotics	quantitative (%)
Number of vascular plants	quantitative
Uses and activities features	
Beach facilites	quantitative (%)
Building types	multistage
Urbanisation density	multistage
Paved coastal avenue	quantitative (m)
Density of tents and parasols	quantitative (number/m)
Mean length of tent area (m)	quantitative (m)
Number and type of vehicle tracks as an estimation of vehicular traffic	multistage, quantitative
Presence of footing and fishing activities	quantitative (%)
Camping facilities	binary

Within each sampling site we set sampling lots. We stratified them into woody (ATW; *Acacia* - *Tamarix* woodland) and open dune vegetation (PG; *Panicum* grasslands). We chose this sampling design after an initial field reconnaissance of the surveyed area together with the analysis of the satellite images we had used to characterize the area. We set the size of the sampling plots by estimating a minimal area. Because dune vegetation was fairly homogeneous, the sampling area found was 10 m^2 for PG and 25 m^2 for ATW.

In the context of the current study we recorded 111 vascular plants. Native plants are species with a natural geographical range within conterminous Argentina. Among are those immigrants introduced from other plant communities. Exotics immigrants (non-native species) are defined here as introduced alien species.

DATA ANALYSIS

Firstly we analysed data that summarized geophysical, landscape, uses and activities variables.

Secondly we compare, in the urban beaches and in natural dune areas, the cover of native and exotic vascular plants discriminated in dune and immigrant species.

To compare the plant composition we assessed the floristic similarity between two species assemblages with Sorensen's *SI* index (Sorensen, 1948).

$SI = 2a / 2a + b + c$

a = number of plants common to the two sampled areas; b = number of plants in site 1 and c = number of plants in site 2.

SI values higher than 0.75 were considered to reflect *very high* similarity, those in the range 0.51 – 0.75 reflected *high* similarity, and those between 0.26 – 0.50 were indicative of *moderate* similarity. *Low* similarity corresponded to *SI* values lower than 0.25 (Ratliff, 1993).

We assessed the impact of recreation and tourism during the second half of the 20th century on dune plant communities. To do this, we calculated total similarity of the current botanical composition of vegetation in dune fields and urban centres with the past dune botanical composition, obtained from plant inventories made in the 1940s (Cabrera, 1941).

We were also interested in identifying which species (or groups of them) were mostly responsible for either species additions or losses from plant assemblages (Schwartz *et al.,* 2006). To this end we calculated *SI* values for 4 groups of taxa classified into *natives, exotics, dune obligate* or *immigrant* species.

Finally we computed the correlations among all species cover in order to detect redundancies and to choose indicators that best predict anthropogenic impacts.

We log transformed all variable data with the equation: y'= log10 (y+1); where y is the observed datum. We used a forward stepwise method to do a discriminant function analysis with the transformed data to identify the set of variables that did the best separation of groups made up according to the different hypothesis postulated by us. That method reviews all selected variables at each step and includes in the model the one that contributes more to the discrimination between groups. We chose a priori probabilities proportional to group size.

RESULTS

Along the beach gradient type and number of uses and activities changed (Fig. 2). At urban beaches the mean number of activities accounted to 5.2 decreasing afterwards (4 at 2 km, 4.3 at 5 km and 3.5 activities at 10 km)

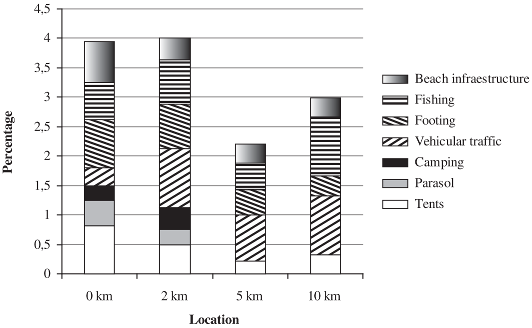

Figure 2. Uses and activities in the beach at different locations
Figure 2. Frecuencias de usos y actividades en diferentes sitios en los balnearios estudiados

Table 3 shows the six variables among geophysical, landscape and uses and activities features that best discriminated the sampling sites along the land-use gradient.

Table 3. Statistically significant variables associated with the land-use gradient from the town centre to the natural areas
Tabla 3. Variables con diferencias estadísticas significativas asociadas al gradiente de uso desde los sitios urbanizados a áreas naturales

	Urban beach			
	0 km	**2 km**	**5 km**	**10 km**
Mean length of tent area (m)	1.93	0	0	0
Mean tent density (tents / meter)	55.11	0	0	0
Beach facilities (%)	0.867	0.5	0.278	0.167
Mean paved coastal avenue (m)	2.72	0.56	0.22	0.167
Footing (%)	1	0.25	0.44	0.167
Mean herbs cover (%)	27.44	68.75	34.4	47.5

Tents and parasols for shade are more conspicuous towards the centre. Beach infrastructure and paved centre where herbs cover showed the lowest value (Table 3).

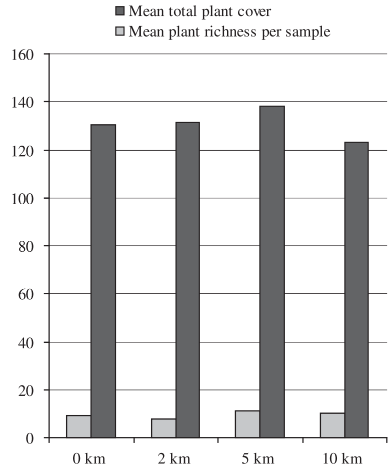

Figure 3. Richness and total plant cover
Figura 3. Riqueza y cobertura total vegetal

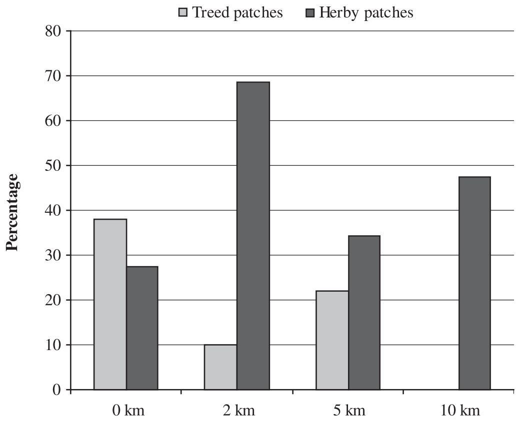

Figure 4. Cover of treed and herby patches
Figura 4. Cobertura de parches arbóreos y herbáceos

Figure 3 showed that at the ecosystem level there was no difference in mean plant richness per sample and total plant cover in the four selected locations. However at the patch level (Figure 4) herbs cover significantly decreased at the urban beaches, while treed patches increased.

Table 4. Self growing species that best predict anthropogenic disturbances
Tabla 4. Especies espontáneas indicadoras de disturbios humanos

	0 km (urban beach)	**2 km**	**5 km**	**10 km**
Natives	*Bromus catharticus*	*Poa lanuginosa*	*Jarava plumosa* *Margyricarpus Pinnatus* *Tessaria Absinthioides*	*Solanum Chacoense* *Cortaderia Selloana* *Cenchrus Pauciflorus* *Achryrocline Satureoides*
Cover %	10	10	19	21
Exotics	*Brassica campestris* *Festuca arundinacea* *Taraxacum Officinale*	*Calystegia Soldanella* *Gazania linearis*	*Lonicera japonica* *Polypogon Monspeliensis*	*Centaurea Calcitrapa* *Sonchus asper*
Cover %	3.90	3.07	5.90	7

Table 4 shows the self growing native and exotic species with largest importance values for discriminating the anthropogenic disturbance gradient along the coast. In each case they account for 71. 23 % of the total variance.

Among the self growing species, the cover of native and exotic plants was lowest at the centre and 2-km sites, but it almost doubled farther away.

We detected statistically significant correlations between some species cover. The vine *Lonicera japonica* was positively correlated ($P = < 0.01$) with white poplar (*Populus alba)*, but it was not correlated with other trees planted for binding dunes, such as *Tamarix gallica, Myoporum laetum* and *Acacia melanoxylon.*

Tamarix gallica was positively correlated with the cover of *Baccharis rufescens* ($P = < 0.05$) and *Myoporum laetum* and *Populus alba* were correlated positively with *Chenopodium album* ($P = < 0.003$).

We focused next our analysis on both extremes of the gradient (Table 5).

Table 5. Average cover values of dune and immigrant species – both natives and exotics – at dune fields and urban beaches

Tabla 5. Promedio de valores de cobertura de especies de duna e inmigrantes –nativas y exóticas – en playas urbanas y dunas naturales

Plant species	**Urban beaches** **0 km**	**Dune fields** **10 km from center**
Dune native		
*Margyricarpus pinnatus**	0.73	2
*Calycera crassifolia**	2.77	5
*Cenchrus pauciflorus**	0.34	
*Conyza bonariensis**	0.8	2.5
*Cortaderia selloana**	2.05	3.75
*Hydrocotile bonariensis**	4.89	10
*Oenothera mollissima**	1.82	4
*Panicum racemosum**	24.09	55
Apium prostratum	0.11	
*Baccharis rufescens**	0.23	
*Poa lanuginosa**	2.27	
*Rumex cuneifolius**	0.57	
*Achryrocline satureoides**	0.45	3
*Senecio quequensis**	0.27	
*Spartina coarctata**	4.55	
*Conyza chilensis**	0.34	
Senecio montevidensis	0.23	
Eryngium eburneum	0.57	
Jarava plumosa	1.25	
Nassella trichotoma	2.61	
Juncus acutus	0.23	
Melica sp.	0.11	
Phyla canescens	0.11	
Physalis viscosa	0.11	
Salpichroa origanifolia	0.91	
Senecio pinnatus	0.23	
Sporobolus rigens	2.05	
Eleagnus angustifolia	0.11	
*Cynodon dactylon**	2.27	
*Calystegia soldanella**	0.84	
*Polycarpon tetraphyllum**	0.11	
*Salsola kali**	3.18	
*Sonchus oleraceus**	0.80	
*Taraxacum officinale**	0.11	
Arundo donax	0.11	
Populus alba	0.11	
Avena fatua	0.23	
Brassica campestris	0.45	
Carduus acanthoides	0.11	
Onopordum acanthium	0.11	
Centaurium pulchellum	0.11	
Cerastium glomeratum	0.11	
Chenopodium album	0.34	
Cirsium vulgare	0.5	

Dactylis glomerata	0.68
Digitaria sanguinalis	0.23
Echinochloa sp.	0.23
Festuca arundinacea	0.61
Gazania linearis	0.34
Geranium molle	0.11
Hirschfeldia incana	0.34
Hordeum murinum	0.68
Hypochoeris radicata	0.64
Vicia sativa	0.11
Lepidium sp.	0.11
Lobularia maritima	0.11
Lolium multiflorum	0.11
Medicago lupulina	1.32
Melilotus albus	1.82
Melilotus officinalis	0.50
Parietaria debilis	1.82
Plantago lanceolata	0.11
Polypogon monspeliensis	0.64
Potentilla anserina	0.23
Raphanus sativus	0.45
Sporobolus indicus	0.23
Veronica arvensis	0.11

* plants cited in Cabrera (1941)

Total plant cover was larger at the beaches located at the urban centres (131 %) compared with the dune fields (108 %) (Figure 5). The cover of dune plants decreased at the urban beaches, where immigrant natives (15. 85 %) and especially exotics (47. 66 %) were more abundant.

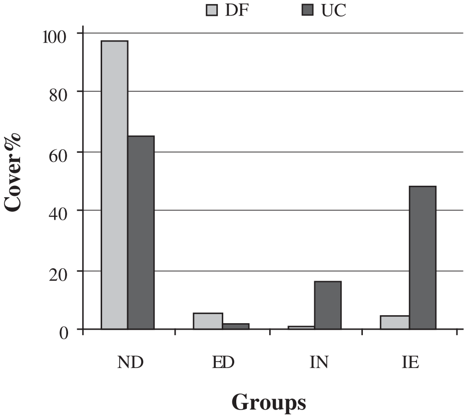

Figure 5. Plants cover average at the urban beaches and dune fields
ND: Native dune plants; ED: Exotic dune plants, IN: Immigrant native plants; IE: Immigrant exotic plants; DF: Dune fields, UC: Urban beaches

Figura 5. Cobertura vegetal promedio en playas urbanas y dunas naturales
ND: plantas nativas de duna; ED: plantas exóticas de duna, IN: plantas nativas inmigrantes; IE: plantas exóticas inmigrantes; DF: Dunas naturales, UC: Playas urbanas

COMPARISON OF DUNE FIELDS WITH URBAN BEACHES

The floristic similarity between the vegetation from the dunes remote from urban centres and those closest to these was low (*SI* = 0.21). On the contrary, the comparison of the current floristic composition of the dune fields with the past one showed a high similarity (*SI* = 0.60) between plant assemblages.

In regards to dune obligate species we found a very high similarity between dunes close to the urban centre and those away from it for both natives (*SI* = 0.86) and the only exotic species recorded in that class: *Cakile maritima* (*SI* = 1).

As to immigrant plants dune field and urban beaches had completely dissimilar assemblages of both natives (*SI* = 0.086) and exotics (*SI* = 0.21).

DISCUSSION

In beach resorts changes in land use resulting from urbanization and activities associated with tourism are usually recognised as a principal driving force behind biodiversity change (Lemauviel & Rozé, 2003). Temporal and spatial comparisons of plant inventories from many cities of the world show that urbanization promotes the loss or decline of native species and their replacement by immigrants, including exotics to a given country or region (Mc Kinney, 2005; Schwartz *et al.,* 2006; Kowarik, 1995; Wittig *et al.,*1985).

Our findings show that five variables linked to 'uses and activities' separated some of the sampling stations from the others along the urban transect in a way that confirmed Dadon's model (1999, 2002), and the theory of the urban-rural gradient put forward by Mac Donnell & Pickett (1990), Mac Donnell *et al.*, (1997).

None of the geophysical variables used discriminated among sampling stations; i.e. habitat conditions were mostly similar across them. Among the landscape features only one –*cover* of *herb patches* – significantly differed among sampling stations.

As one of the consequences of the dynamics of urbanisation is that native ecosystems are replaced by paved surfaces and buildings, and alien ornamental species make up the urban green spaces, the residual natural vegetation also experiences changes in species assemblages (Pauchard *et al.*, 2006; Mc Kinney, 2006). Our observations confirmed that since the second half of the 20th century plant species gains or losses from natural assemblages were connected to anthropogenic forces. The high similarity of the vegetation of areas located 10 km away from the urban centres with pristine original communities as recorded by Cabrera (1941) suggests that the former remained beyond human reach.

Similarity measures for *dune obligate* species showed that they were shared between urban centres and remote areas. On the contrary, *immigrant* plants brought about a substantial differentiation among those areas. Their relatively small similarity values gave notice of important gains in native and exotic immigrants by the urban centres.

The current spatial comparison confirmed the gradient hypothesis put forward for explaining changes in plant assemblages. As we found in the current study, the number of exotics increased substantially towards the urban centres; this trend agrees with many authors' opinion that urbanization is responsible for plants communities richer in exotics. (Kowarik, 1995; Sukopp, 1998). Our results support the hypothesis that urban and suburban areas are important sources for spread of introduced plant species (Duguay *et al.,* 2007). Many causes can explain this enrichment. Sand stabilization can increase species richness with contraction of bare dunes (Kutiel *et al.,* 2004). Soil compaction from trampling and vehicle circulation induces soil sealing and thereby stimulates an increase of vegetation cover (Liddle & Greig Smith, 1975). As trampling and traffic tend to follow well-defined tracks they can also facilitate the establishment of invading species along them (Levin & Ben Dor, 2004). Talora *et al.* (2007) found that after trampling species from nearby areas colonized the dunes, increasing the diversity. The development of soil and cryptogamic crusts on the surface of stabilized dunes enhanced the colonization and establishment of herbs due to increasing water availability, clay and silt content and soil nutrients. (Li *et al.*, 2007).

In our study case intense vehicular traffic and water runoff due to the paved surfaces at the urban centres apparently modifies soil chemical composition (Beach, 2002). Additionally the urban storm drainage system carries undesirable solids, organic material, nutrients and toxic substances to the beach (Clark, 1996).

Exotics were more effective than natives as indicators of anthropogenic impact. Weeds like *Brassica campestris* and *Taraxacum officinale* and also the grass *Festuca arundinacea* were exclusively present at the urban centres. As urban adapters, they indicate rich soils, and thus can be associated with *eutrophication* processes taking place near settlements.

Among the native plants that discriminated sampling stations we can recognise some that behaved as "adapters" and "avoiders" (Mc Kinney, 2006). *Bromus catharticus* is a good example of an adapter. This lawn grass picked spontaneously at the urban centres. Another one is *Poa lanuginosa,* which showed its maximum cover at 2 km from the urban centre. Other adapters are *Jarava plumosa*, a grass that migrates from neighbouring grasslands, and two forbs – *Margyricarpus pinnatus* and *Tessaria absinthioides* – which are characteristic heliophytes (Cordazzo *et al.,* 2006; Faggi & Dadon, 2007). On the contrary, avoiders of urbanized environments are *Solanum chacoense, Cenchrus pauciflorus, Cortaderia selloana* and *Acryrocline satureoides,* which grew as plants common for open dunes at the 10 km-stations.

Other exotic spontaneous plants like *Gazania linearis, Lagurus ovatus, Lobularia maritima*, *Festuca arundinacea* are either associated with or have escaped from gardens. *Gazania linearis* was present only at sites located 2 km from urban centres, where houses with front gardens are very frequent. It is an ornamental low-growing perennial herb with yellow flowers, native to South Africa that has become naturalised on coastal dunes. It is very much appreciated in most domestic gardens as a drought-tolerant ground cover. Its popularity is favoured by its ample supply and low retail price. *Festuca arundinacea* is also used for lawns and is a regular component in commercial seed mixtures.

Ornamental horticulture has been recognised as the most important vehicle for spreading plant invasions worldwide; there is a link between propagule pressure and capability to become established in the wild (Dehnen-Schmutz *et al.*, 2007). Market supply, price and demand for easily cultivated plants like the just mentioned exotics, are significantly explanatory causes of escape from gardens (Dehnen-Schmutz & Williamson, 2006), while biological variables like annuality, salt resistance, high seed production, vegetative multiplication, and fauna as propagule dispersers are more relevant at the stage of plant establishment.

Some plants were deliberately introduced for dune reclamation: the succulent *Carpobrotus edulis* and trees like *Acacia melanoxylon* and *Tamarix gallica*. These new man-made canopies facilitated the unintentional introduction of other plants later.

A known effect of afforestation on plant dispersal is the trapping of wind-dispersed propagules by the tree canopy (Aguiar & Sala, 1997). This could be the reason that explains the occurrence of exotic *Populus alba* (white poplar) at the urban centres. The same explanation seems fit for accounting the presence of many small-seeded herbs and grasses. A good example of this is *Polypogon monspeliensis* ('annual rabbitsfoot grass'), which cover peaked at the 5-km stations. From European origin, it spreads on moist soils and produces abundant seeds very much foraged by birds – e.g. Ground-Dove, House and Rufus-collared Picui Sparrows. Although large flocks of these birds were commonly observed foraging during the field inventories, it is likely that only a minor proportion of eaten seeds can be expected to be dispersed because most of them are digested. As tree cover is also important at these stations, the tree canopy could operate as a trap of seeds blown by wind. *Lagurus ovatus* (Hare's Tail Grass) – an ornamental grass escaped of cultivation – and many other native plants (e.g. Asteraceae) are also easily spread by wind.

The planned replacement of the plant canopy from open natural grasslands with a comparatively closed and tall tree canopy could facilitate the recruitment of spontaneous alien trees. The resulting vertical structure of the planted woodlands might indirectly have had a positive effect on seed dispersal by increasing the population of perching birds to them, which facilitate the dispersal of the seeds of the Russian olive tree *(Elaeagnus angustifolia)* and of the vines like *Passiflora coerulea* (native) and *Lonicera japonica* (exotic). *Lonicera japonica* was only found at sites located at 5 km from the city core. The honeysuckle is an invasive ornithocore climber from Asia used as an ornamental, but it has escaped cultivation and become a significant weed in many regions in Argentina. Its dispersion is linked to perching birds visiting tree canopies for shelter and food, especially *Populus alba*'s. We found a statistically significant correlation between the abundance of this speciesand honeysuckle's. *Populus alba* spreads rashly at the landward side of the dunes. Montaldo (2005) found that the birds *Pitangus sulphuratus*, *Turdus rufiventris* and *Elaenia parvirostris* feed on *L. japonica* fruits. During sampling we could observed these birds in the study area. No correlation was found between honeysuckle abundance with other trees such as *Tamarix gallica, Acacia melanoxylon* and *Myoporum laetum* exposed to wind, indicating that perching birds would select these calm sites.

Our evidences showed that under a wooded canopy, reduced light flux displaced most of the original shade intolerant native plants like *Achryrocline satureoides, Margyricarpus pinnatus, Solidago chilensis, Oenothera mollissima* and *Panicum racemosum*. They were replaced by immigrant plants which dispersal was eased by agricultural, gardening, and recreational activities as well as the agency of animals.

The influence of afforestation on changes in plant assemblages as shown by the presence of native plants like *Salpichroa origanifolia*, *Passiflora coerulea* and *Cestrum parquii* – normally found in forest understories – could also be felt at the urban centres.

Some mesic immigrant plants found there – *Eryngium eburneum, Juncus acutus, Salpichroa origanifolia, Phyla canescens, Physalis viscosa, Pluchea sagittalis. Centaurium pulchellum, Cerastium glomeratum* and *Echinochloa* sp. – support our hypothese that higher run-off and artificial irrigation increase soil moisture at the resort centres. Soil compaction by trampling is another factor which can be beneficial for mesic vegetation in dune habitats (Liddle & Greig-Smith, 1975; Levin & Ben Dor, 2004). Our findings are consistent with those from Grunewald (2005), who compared the influence of recreational activities on the natural phytodiversity of tertiary dunes. He concluded that especially trampling, eutrophication, and the neighboring effects of nearby gardens, parks, or fallow land, were the main factors influencing plant diversity.

The composition of plant assemblages at intermediate sites along the urban transect reflected transitional situations between city cores and natural areas. We found a trend to higher mean plant richness per sample and total plant cover at 5 km, which can be explained by the Connell's intermediate disturbance hypothesis (Connell, 1978). According to this plant diversity would peak at intermediate points of a disturbance gradient when a variety of species had colonized a habitat but disturbances are not so extreme for competitive exclusion to take place. In the present case the landscape at 5 km from the town centre looks very much like a suburb with scarce woods, disperse houses with gardens, and regular human pressure. Higher floristic diversity in the suburbs is frequently reported in literature (Kowarik, 1995; Mc Kinney, 2006).

CONCLUSIONS

Our research showed that tourism has been the main driving force of changes in plant composition in town resorts located along the northern Atlantic beaches of Argentina. Plant homogenisation has been the outcome of the loss of sensitive dune plants and plant assemblage differentiation by the gain of immigrant species.

In city cores and adjacent areas, man-made new microhabitats encouraged non-native plants to displace most of the native assemblages during the urban growth process. Away from there vegetation composition was the same as the pristine original communities.

Eutrophication and *Urban green* affected the distribution and abundance of indicators species. Both belong to the factors: favourable *"habitat"* for establishment and "*transportation*"- importation of exotics- that Mc Kinney (2006) singled out as the veritable causes of the regularly observed biological patterns in cities.

Finally, our study highlights the importance of giving due consideration to the conservation of native biodiversity when planning new resorts along the beach; e.g. by leaving distances between neighbouring resorts long enough to guarantee the persistence of natural communities.

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