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# Do anthropogenic corridors homogenize plant communities at a local scale? A case studied in Tenerife (Canary Islands)

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**Abstract** Biological homogenization is defined as a process that occurs when native species are replaced by common and dominant exotic species or due to depletion and expansion of native species, reducing the beta diversity between areas or habitats. Islands are particularly vulnerable to plant invasion, and as a consequence, homogenization is a process that can become faster and more intense in islands than in continental areas. We recorded vascular plant species composition in roadside communities along a strong altitudinal gradient using plots beside the road and at two distances from the road (0–50 and 50–100 m). We analyzed the results separately for each group of plots with a Detrended Correspondence Analysis (DCA) including and excluding exotic species. The results revealed that where exotic species were most abundant, i.e., at the road edge, they can create an effect of floristic homogenization where three similar roads are compared. At a distance of >50 m from the road, where exotic species are less frequent, this effect has already disappeared, indicating that it is a local phenomenon, closely related to the highly disturbed roadside environment. Furthermore, floristic homogenization seems to be more important at higher altitudes (>1000 m), probably related to higher diversity in native plant communities and lower levels of human disturbances. Roads allow humans to reach relatively remote and sometimes well-conserved areas, and, at the same time, facilitate the spread of exotic plants and the most common native species which can locally create floristic homogenization in roadside communities on this oceanic island. A deeper understanding of the effects of these anthropogenic corridors at the local and regional scales is therefore required to integrate road planning and management with the aim of conserving the value of the natural areas.

**Keywords** Exotics species · Species composition · Altitude · DCA · Road management

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## Introduction

Urbanization is one of the main causes of biotic homogenization (McKinney 2006; Kuehn and Klotz 2006). However, floristic homogenization is not unequivocally related to urbanization or population density (Qian et al. 2008) and depends also on the distance between compared regions (Qian and

Ricklefs 2006). Abundant invasive species with a large geographic range tend to enhance the homogenizing effect (McKinney and La Sorte 2007). One of the landscape effects of urbanization is the road system, which is a source of biotic and abiotic effects on the surrounding landscape (Bennet 1991) and the resulting corridors, leads to significant human activity (Forman and Alexander 1998). Roads sharply define and fragment forest ecosystems. Plant species composition and the vegetation structure change from road edges to the surrounding interior (Łuczaj 1999; Cavieres et al. 2005). Also, spatio-temporal dynamics at the forest edge differ from the interior (Matlack 1994), and this edge could be natural or an anthropogenic disturbance.

Roads are also one of the most important causes of the dispersal of exotic species (Arévalo et al. 2005; van der Lippe and Kowarik 2007a). Dispersal of plants along roads may accelerate plant invasions, inducing rapid changes in biodiversity patterns, especially on road verges, where the disturbance effect of the anthropogenic corridor is more evident (Arteaga et al. 2009; Arévalo et al. 2008; Delgado et al. 2001). This process destroys native habitats and creates new habitats for species adapted to human-disturbed environments (Scott and Helfman 2001). The homogenizing effect of roads has not been studied in sufficient depth on oceanic islands, although homogenization can lead to local species extinction and the sprawl of introduced and generalist species, resulting in a loss of global biodiversity at different scales (McKinney and Lockwood 1999; Rahel 2000, 2002).

Oceanic islands worldwide are being severely changed and constrained by the pressures of urbanization and transport infrastructure (Whittaker 1998; Song et al. 2005). The Canary Islands have the highest road density of all the European islands (Martín and Fernández-Palacios 2001). In Tenerife, paved roads occupy 3% of the island surface.

In this study we aimed to explore the role of roads in the process of biotic homogenization centering the study at the level of plant communities on Tenerife. We analyzed the roadside community of vascular plants along three roads, ranging from coastal to high mountain habitats on the island, and evaluated the changes in the plant community from the road edge to the interior of the surrounding habitat matrix. The hypothesis we aimed to test is that exotic species homogenize plant community composition in the vicinity of the roads and interior habitat.

Advances in policy and technology can greatly slow down the homogenization process or even stop it (Simberloff 2001). The results should help in the design of restoration programs and provide information for a better management and protection program of protected areas divided by roads.

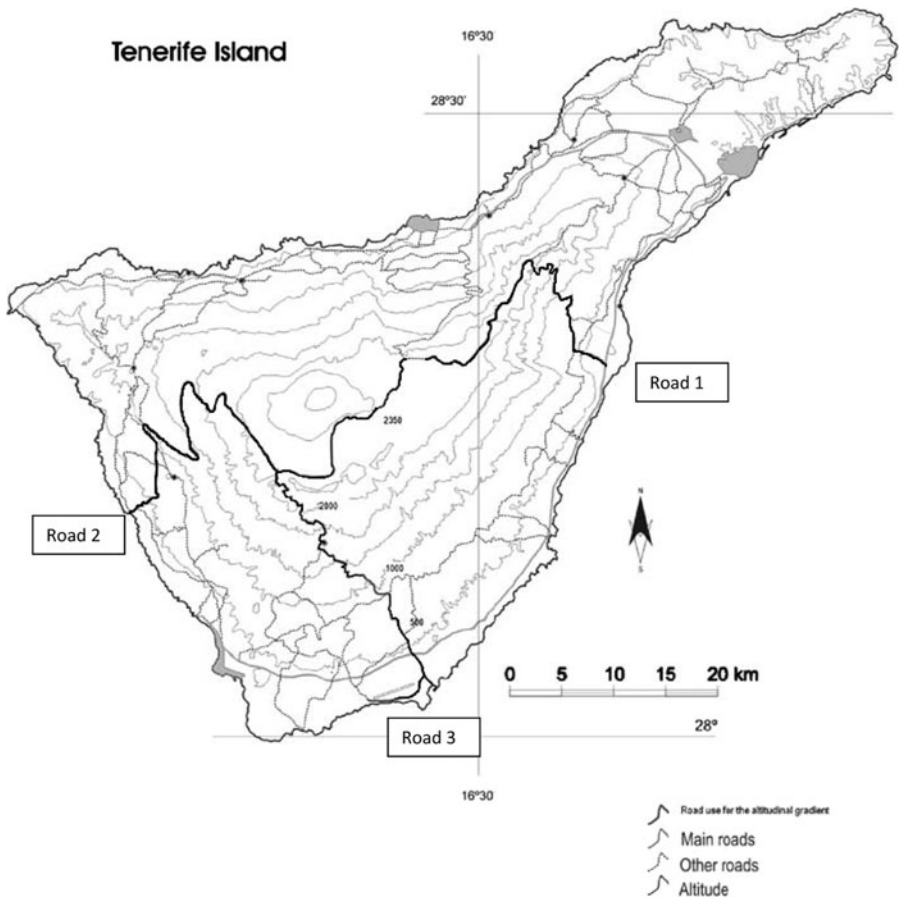
## Materials and methods

### Study site

The three roads studied were located in the Southwest, South, and Southeast of the island of Tenerife. These were single carriage roads about 50 km apart on the coast, reaching the same point in the volcanic caldera of Las Cañadas del Teide National Park (2200–2350 m a.s.l.) (Fig. 1). Therefore, these roads encompass comparable altitudinal gradients and show similar characteristics in their construction (size, material) and traffic use, and all face south. Vegetation communities of the surroundings vary from halophytic communities at the coast, tough succulent scrub in the lower regions, pine forest between 800 and 2000 m, and high mountain shrub communities above the timber line. Precipitation ranges from 150 to 700 mm at some points of the pine forest (Díaz-Díaz et al. 1999). Mean annual temperature varies from 22°C on the coast to approximately 11°C at the highest segments of the road. Soils are classified in general as litosoils at lower altitudes, pumitic soils, and vertic soils between 800 and 1400 m a.s.l. and cambisols at higher altitude (Rodríguez and Mora 2000).

### Vegetation sampling

On each 100 m altitudinal belt, we located one plot selected randomly at one side of the road (if both sides were possible), starting right at the end of the pave road. One plot was 50 × 2 m in size with the larger side of the rectangle parallel to the road. Then, we located another plot 50 × 2 m, perpendicular to and starting in the middle of the first one (call the intermediate plot) and an interior plot (2 m wide from 50 to 100 m at right angle from the road edge) (Fig. 2). Sampling of all vascular plant species was



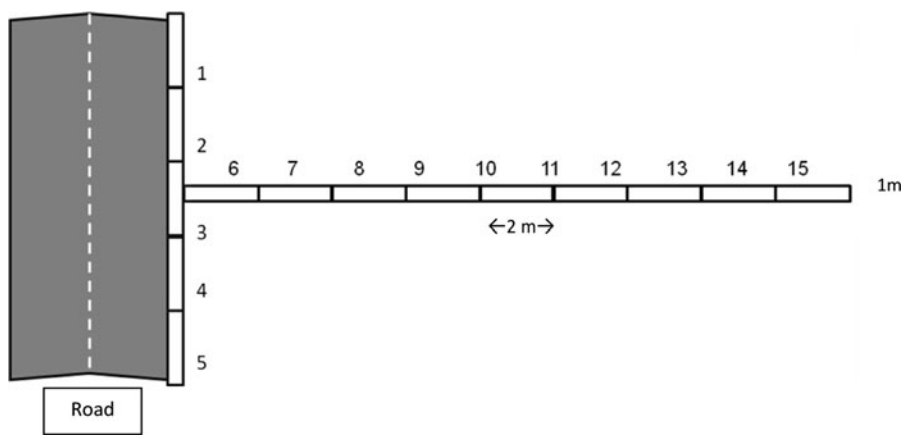




**Fig. 1** Tenerife island, indicating the three roads segments studied. Road number indicates at coast level

**Fig. 2** Sampling design. Plots 1–5 are border, 6–10 intermediate, and from 11 to 15 interior plots

conducted from January to April 2007. Abundance of species was recorded in three density classes (1: less than ten individuals, 2: 10–100 individuals, 3: more than 100 individuals). We measured altitude (m) in each plot.

## Statistical analysis

Ordination techniques help to explain community variation (Gauch 1982) and they can be used to evaluate trends through time as well as space

(Franklin et al. 1993; ter Braak and Šmilauer 1998). We used the indirect gradient analysis, Detrended Correspondence Analysis (DCA; Hill and Gauch 1980), to examine how species composition changed through space, based on species density. We analyzed the data from the three differentiated portions of the transect separately (edge, intermediate, and interior) twice, firstly with all the species present and secondly removing the exotic species listed in the checklist of Izquierdo et al. (2004).

Instead of using similarity indices (Jaccard or Simpson Index) as reported for most regional studies on biotic homogenization (Oden and Rooney 2006; Qian et al. 2008), the application of multivariate statistics is a suitable method for comparing changes in beta diversity at the community or habitat level (Magee et al. 2008). Furthermore, it has the advantage of accounting for species abundance and measuring homogenization not only on the basis of shared species, which would probably underestimate the homogenizing impacts of non-native species (McKinney and La Sorte 2007).

To discriminate the three roads in terms of species composition, we analyzed the species scores of the plots for the DCA axis II with a Kruskal–Wallis test (for a $P < 0.05$). To reveal the relationship of the DCA axis I scores of the plots with altitude, we calculated the Pearson correlation coefficient among these variables. Altitude is the strongest environmental gradient on the island (Arévalo et al. 2005; Fernández-Palacios and de Nicolás 1995). Significant differences of axis II scores will indicate discrimination in terms of species composition related to the different roads studied. If floristic differences between roads based on natives disappear when exotic species are included, then we will be able to detect a reduction in beta diversity between the roadside communities due to the presence and abundance of exotic species, i.e., the effect of floristic homogenization.

Differences in mean number of species in the edge, intermediate, and interior plots, as well as in the percentage of exotic species were analyzed with a Kruskal–Wallis test (for a $P < 0.05$).

We performed all multivariate analyses and the forward analysis selections with the CANOCO package (ter Braak and Šmilauer 1998). Basic statistical methods followed Zar (1984) and were implemented using the SPSS statistical package (Anonymous 2003).

## Results

For the edge plots of all three roads, we found a total of 201 species, 192 species for the intermediate plots and 186 for the interior plots. The percentages of exotic species were 15.9, 11.4, and 8.6, respectively. When the values were separated per road, the same trend in the results was found, with more species and more exotic species in the edge plots and a declining number through to the interior plots (Table 1). We

**Table 1** Summary of the species at the different plots areas per road. Total species (total sp.), exotic species (intr sp.), and percentage of exotic over the total number (% introduce) are indicated per road and pooled data for the tree roads

| Plot location | Total sp. | Exotic sp. | Exotic % | Pooled roads | | |
|---|---|---|---|---|---|---|
| | | | | Total sp. | Exotic sp. | Exotic % |
| Edge | | | | | | |
| Road 1 | 114 | 16 | 14.0 | | | |
| Road 2 | 112 | 12 | 10.7 | 201 | 32 | 15.9 |
| Road 3 | 108 | 12 | 11.1 | | | |
| Intermediate | | | | | | |
| Road 1 | 114 | 18 | 15.8 | | | |
| Road 2 | 98 | 9 | 9.2 | 192 | 22 | 11.4 |
| Road 3 | 99 | 12 | 12.1 | | | |
| Interior | | | | | | |
| Road 1 | 107 | 14 | 13.1 | | | |
| Road 2 | 106 | 10 | 9.4 | 186 | 16 | 8.6 |
| Road 3 | 102 | 8 | 7.8 | | | |

did not find significant differences in the number of species along the road edge, intermediate plots, and interior plots. However, the mean percentage of exotic species decreased significantly from edge to interior ($\chi^2_2 = 6.58$, $P < 0.05$).

As for the DCA analysis for the edge plots, we could not discriminate between roads (Fig. 3a) on the second axis, when including all species. A strong gradient is established from coast to the high mountain on the DCA axis I, with the coastal plots dominated by native species such as *Patellifolia patellaris*, *Forsskaolea angustifolia*, and *Plocama pendula* or exotic shrubs and forbs, including *Opuntia ficus-indica* or *Conyza bonariensis*, whereas at the upper road plots native shrubs like *Pterocephalus lasiospermus* or *Adenocarpus viscosus* dominate (Fig. 3b). For all the DCA analyses, the axis I coordinate of plots is significantly positively correlated with altitude (for a $P < 0.01$).

When the exotic species are removed, the discrimination between the roads by DCA axis II becomes stronger (Fig. 3c). The Kruskal–Wallis analysis revealed for the first case no significant differences between the scores of the roads for axis II ($\chi^2_2 = 12.502$, $P > 0.05$), while the difference becomes significant once the non-native species are removed ($\chi^2_2 = 26.161$, $P < 0.01$), indicating the effect of floristic homogenization.

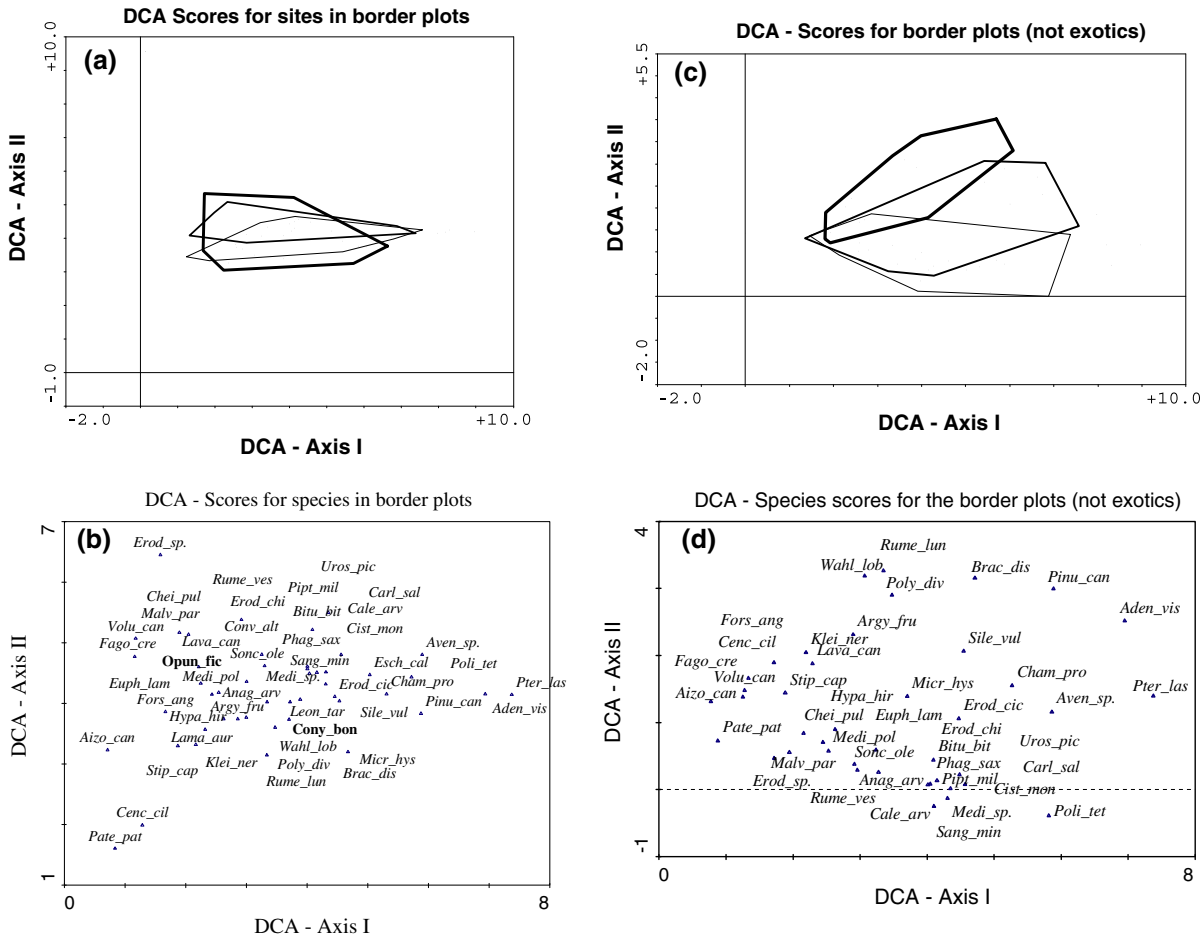



**Fig. 3** DCA axes I and II for **a** site scores of edge plots with polygons enclose 95% of the plots of the three roads, **b** species scores in the same analysis (with exotics species in *bold*), **c** site scores once remove all the introduce species from the lists, and **d** species scores in the same analysis. In the analysis only species with more than 20% frequency are indicate and species names are indicated with the four-first letters of genus and three letters of the species name (Appendix, Table 3)

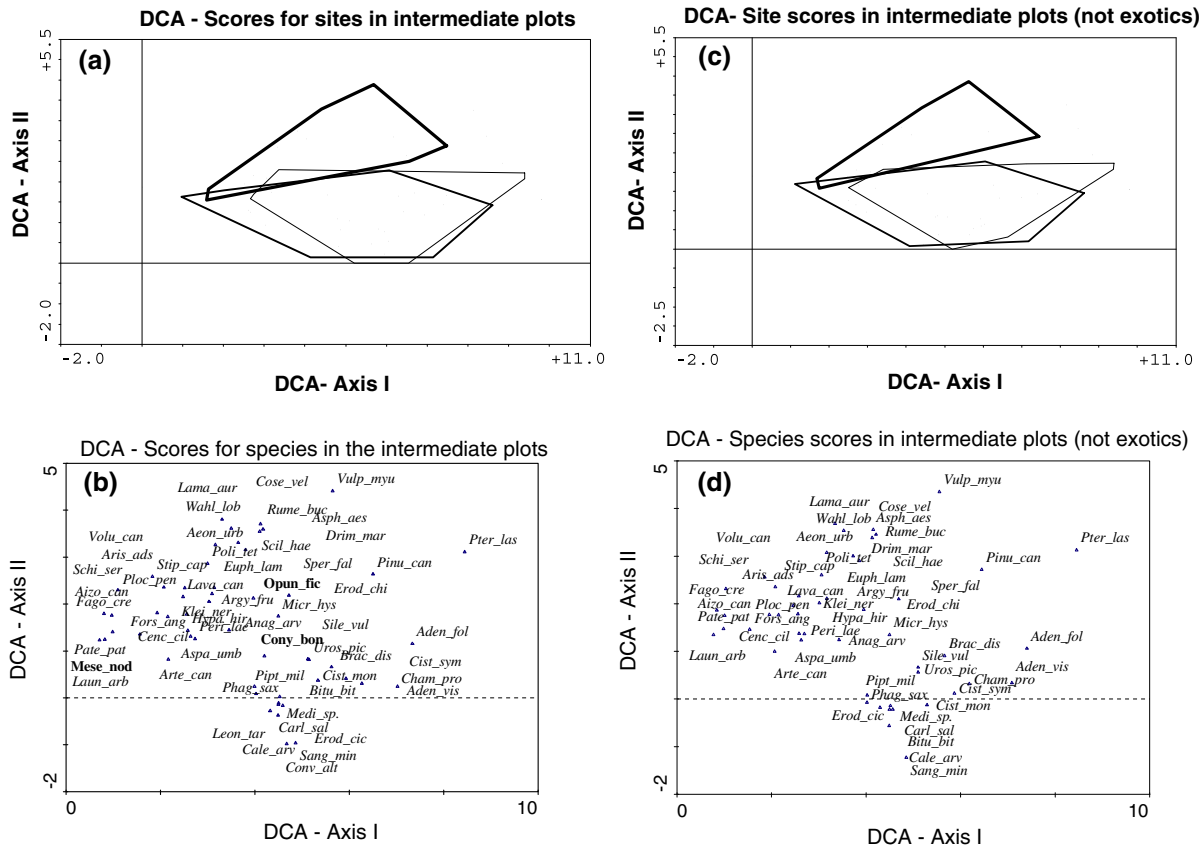



**Fig. 4** Same figures of the DCA analysis as in Fig. 2 but now using the intermediate plots

When we analyzed the intermediate plots, the results followed a pattern similar to that of the edge plot analysis (Fig. 4a, c). However, the roads can be significantly discriminated by the Kruskal–Wallis test with and without exotic species included in the analysis ($\chi^2_2 = 27.964$, $P < 0.01$ and $\chi^2_2 = 27.105$, $P < 0.01$, respectively). Dominant species at low altitudes (lower scores in the axis I) were *Aizoon canariense*, *Notoceras bicorne*, *Mesembryanthemum nodiflorum*, and *M. crystallinum*, and *Fagonia cretica*, whereas at higher altitude *Descourania bourgeauana*, *Pterocephalus lasiospermus*, and *Spartocytisus supranubius* (Fig. 4b) were dominant. When exotic species are removed, dominant species at higher altitude remain the same, but in coastal areas *Patellifolia patellaris*, *A. canariense*, *Launaea arborecens*, and *F. cretica* become more important species (Fig. 4d).

The analyses for the interior plots show almost identical distribution of the plot scores, revealing no differences both including and excluding exotic species (Fig. 5a, c). As before, the three roads are significantly discriminated by the Kruskal–Wallis analysis in both cases (with aliens: $\chi^2_2 = 21.053$, $P < 0.01$; aliens excluded: $\chi^2_2 = 19.787$, $P < 0.01$, respectively). Dominant species at low altitude were *Fagonia cretica*, *Aizoon canariense*, and *Patellifolia patellaris*, whereas at higher altitude *Pterocephalus lasiospermus*, *Adenocarpus foliolosus*, and *Galium parisiense* were dominant (Fig. 5b, d).

Total inertia decreased by less than 15% from road edge to interior, while the percentage of variability explained by axes I and II increased by around 10% (Table 2).

## Discussion

Despite the fact that many studies report a loss in native species due to an increase in exotic species

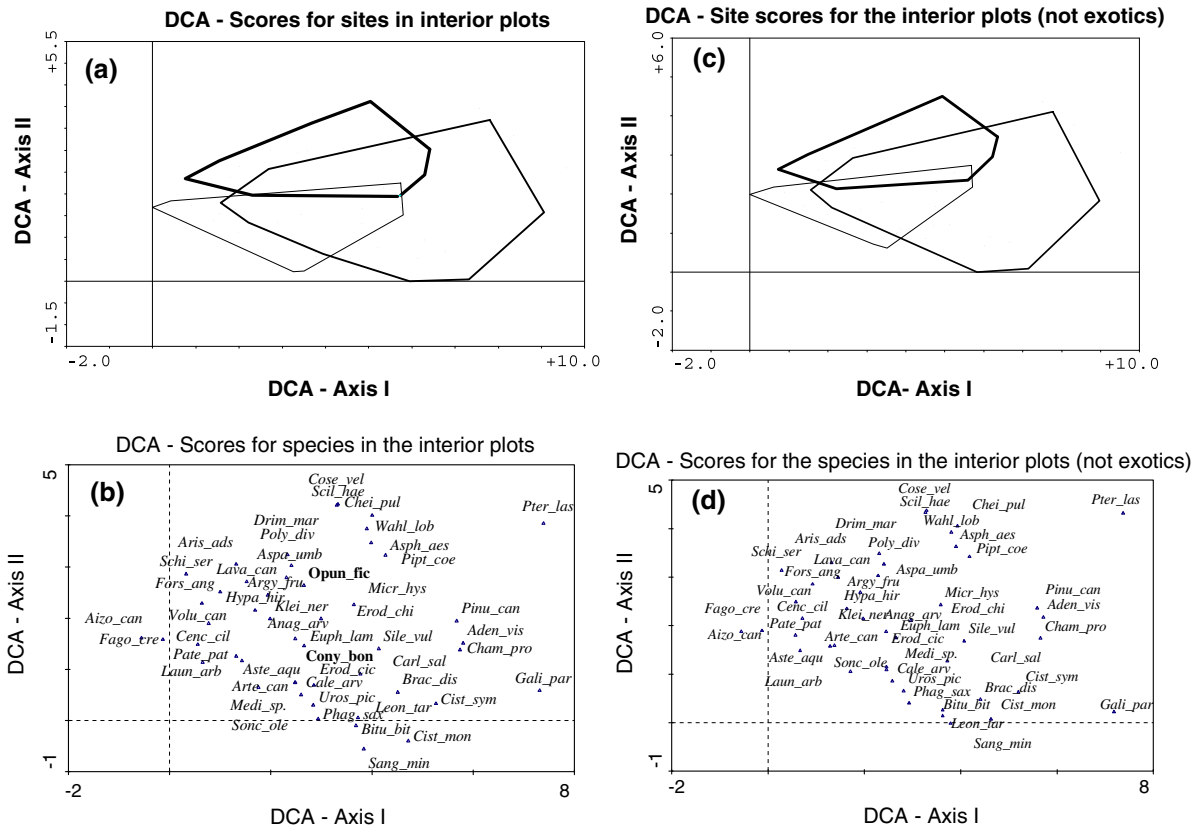



**Fig. 5** Same figures of the DCA analysis as in Fig. 2 but now using the interior plots

**Table 2** Eigenvalues of the Detrended Correspondence Analysis for axes I and II, % of explained variance, and total inertia, for the analysis including exotic species (with exot) and removing the exotic species (non-exot)

| Plot location | Eigenvalues | | % explained | Total inertia |
|---|---|---|---|---|
| | Axis I | Axis II | variance | |
| Edge | | | | |
| With exot | 0.754 | 0.519 | 12.5 | 10.199 |
| Non-exot | 0.753 | 0.477 | 13.0 | 9.441 |
| Intermediate | | | | |
| With exot | 0.816 | 0.521 | 14.6 | 9.127 |
| Non-exot | 0.818 | 0.527 | 15.0 | 8.985 |
| Interior | | | | |
| With exot | 0.780 | 0.485 | 14.3 | 8.830 |
| Non-exot | 0.779 | 0.495 | 14.7 | 8.654 |

(Olden and Poff 2003), we did not find any such evidence, as the number of species did not differ significantly between edge and interior; however, the number of exotic species was significantly higher on the road edge. The disturbance generated by the anthropogenic corridor could be responsible for this increase in species (Arévalo et al. 2005; Arévalo et al. 2008), independently of their alien or native character. Also, some other studies found that the destruction produced by the road construction depletes the species richness (Delgado 2004). Some native species will be common only in the border, and will not be found in the interior plots (i.e., *Avena* sp., *Forsskaolea angustifolia*, *Erodium cicutarium*…). It is of note that homogenization effects are scale dependent (Castro and Jaksic 2008), although we did not evaluate this important factor.

With respect to homogenization of plant community composition, the three roads, despite being fairly close and even converging to a single point on the Cañadas del Teide National Park, did show some differences in species composition, especially between roads 1 and 2 compared to road 3. However, this differentiation in plant communities was not

apparent in the edge plots where the exotic species and some native species were more common and abundant (Appendix, Table 3). Once these non-native species were removed, the plots were well discriminated (Fig. 3a, c), especially in the upper part of the altitudinal gradient, where roads are clearly separated in the DCA ordination. This indicates that plant community homogenization is more significant at higher altitudes (>1000 m). Road density and urbanization are much more intensive in the lower coastal regions of Tenerife, and this has also probably promoted the spread of native urban generalist plant species, leading to a homogenization with native species along roadsides.

The differences for intermediate and interior plots (especially for the interior plots) between DCA ordinations of the plots with and without exotic species are almost non-existent, indicating that exotics do not homogenize or differentiate these communities (Figs. 3, 4, 5).

Total inertia can be measuring the diversity present in the data sets, calculated as the total variance in the species data as measured by the chi-square of the sample-by-species table data (ter Braak and Šmilauer 1998). It does not differ between the data sets, even when the exotic species were removed. The decrease in the total inertia of the analysis should be related with the reduction of total species number.

The main results of this study support the hypothesis of an increase in biotic homogenization of plant communities on a local scale due to the spread of common invasive species (or ruderal native species) triggered by human disturbances, as has been extensively revealed in other areas (McKinney and Lockwood 1999; Oden and Rooney 2006; Cassey et al. 2008). Highly urbanized areas such as cities export exotic species via the road network and through dispersal by traffic to more rural areas (van der Lippe and Kowarik 2007a, b). Not only roads but also other linear landscape elements such as streams can homogenize adjacent native plant communities as reported by Magee et al. (2008), and for this, not only exotic species are the responsible of this homogenization.

As human pressure through urbanization increases for islands in general and specifically in the Canary Islands (Whittaker 1998), we expect higher effects of biotic homogenization in the future. The Canary Islands have the highest road density of all European islands (6 km/km$^2$, Martín and Fernández-Palacios 2001) and population has increased in the archipelago by half a million in the last 15 years. This high pressure of human activities will negatively affect the last remnants of natural areas of the island.

Roads and trails permit visitors to come into contact with relatively remote areas and may increase the effect of floristic homogenization in roadside communities at a local scale as confirmed in this study. However, other studies have offered more complex results, as exotic species increased diversity among areas in close proximity, while increasing homogenization was detected when comparing more distance areas (Rejmanek 2000). Moreover, alien flora are not intrinsically more simple than native flora when we compare different habitats on Mediterranean Islands (Lambdon et al. 2008), but the effect of scale on biotic homogenization deserves further analysis. Consequently, a deeper understanding of the effects of these anthropogenic corridors on local and regional scales is required to integrate road planning (Kuiken 1988) and management with the objective of conserving the value of the natural areas.

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## Appendix

See Table 3.

**Table 3** List of the species indicating presence in the road transect 1, 2, or 3

| Species name | Road | | | Species name | Road | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | 1 | 2 | 3 |
| (a) | | | | (b) | | | |
| ***Acacia cyanophylla*** | | | * | *Chenopodium* sp. | * | | |
| ***Acacia* sp.** | | | * | *Cistus monspeliensis* | | * | |
| *Adenocarpus foliolosus* | | * | | *Cistus symphytifolius* | * | * | |
| *Adenocarpus viscosus* | * | * | * | *Convolvulus althaeoides* | * | * | * |
| *Aeonium sedifolium* | | | * | ***Conyza bonariensis*** | * | * | * |
| *Aeonium spathulatum* | | | * | ***Conyza floribunda*** | | | * |
| *Aeonium urbicum* | * | * | * | *Cosentinia vellea* | | | * |
| *Aizoon canariense* | * | * | * | *Crassula tillaea* | | | * |
| *Ajuga iva* | * | | | *Cuscuta* sp. | | | * |
| *Allagopappus dichotomus* | | * | * | ***Cynodon dactylon*** | | | * |
| *Allium* sp. | * | | | *Cynosurus echinatus* | | * | |
| ***Amaranthus viridis*** | | * | | ***Datura innoxia*** | * | | |
| *Anagallis arvensis* | * | * | * | *Descourainia bourgeana* | * | * | |
| *Andryala pinnatifida* | * | * | | ***Digitaria sanguinalis*** | | | * |
| *Arenaria leptoclados* | | | * | *Dittrichia viscosa* | | * | * |
| *Arenaria serpyllifolia* | * | | * | *Drimia maritima* | * | * | * |
| *Argyranthemum frutescens* | * | * | * | *Echium bonnetii* | | * | |
| *Argyranthemum tenerifae* | * | | * | *Echium plantagineum* | * | * | |
| *Aristida adscensionis* | * | * | * | *Echium triste* | | | * |
| *Artemisia canariensis* | * | * | | *Echium virescens* | | * | * |
| *Artemisia thuscula* | | | * | *Echium wildprettii* | * | | * |
| *Asparagus plocamoides* | | | * | *Emex spinosa* | * | * | * |
| *Asparagus umbellatus* | * | * | * | *Eragrostis barrelieri* | | * | * |
| *Asphodelus aestivus* | | * | | *Erodium chium* | * | * | * |
| *Asphodelus ramosus* | * | | * | *Erodium cicutarium* | * | * | * |
| *Asteriscus aquaticus* | * | | * | *Erysimum scoparium* | * | | |
| *Asteriscus sericeus* | | * | | ***Eschscholzia californica*** | | * | |
| *Asterolinon linum-stellatum* | | | * | ***Eucalyptus camaldulensis*** | * | | |
| *Atalanthus capillaris* | | | * | *Euphorbia balsamifera* | * | | * |
| *Atalanthus pinnatus* | | * | | *Euphorbia lamarckii* | * | * | * |
| *Atriplex glauca* var. *ifniensis* | * | | | *Euphorbia segetalis* | * | | |
| ***Atriplex semibaccata*** | * | * | | *Fagonia cretica* | * | * | * |
| *Avena barbata* | * | | * | *Ferula linkii* | * | | |
| *Avena sterilis* | | * | | ***Ficus carica*** | * | | * |
| ***Bidens pilosa*** | * | | | *Filago gallica* | * | * | |
| *Bituminaria bituminosa* | * | * | * | *Filago pyramidata* | * | | * |
| *Brachypodium distachyon* | * | * | * | *Foeniculum vulgare* | * | * | |
| *Brachypodium sylvaticum* | * | | | *Forsskaolea angustifolia* | * | * | * |
| *Briza maxima* | | * | | *Frankenia ericifolia* | * | | |
| *Bromus madritensis* | | | * | *Fumaria muralis* | * | | |
| *Bromus rigidus* | | | * | *Fumaria officinalis* | | * | * |
| *Bromus rubens* | * | | * | *Galactites tomentosa* | * | * | |

**Table 3** continued

| Species name | Road | | | Species name | Road | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | 1 | 2 | 3 |
| *Bromus tectorum* | | | * | *Galium aparine* | | * | |
| *Bryonia verrucosa* | | * | | *Galium parisiense* | | * | * |
| *Bystropogon origanifolius* | | | * | *Galium scabrum* | | * | |
| *Calendula arvensis* | * | * | * | *Geranium dissectum* | | * | |
| *Campylanthus salsoloides* | | | * | *Geranium mollii* | | * | |
| ***Capsella bursa-pastoris*** | | | * | *Geranium robertianun* | | | * |
| *Carlina salicifolia* | * | * | * | *Globularia salicina* | | | * |
| *Carlina xeranthemoides* | * | | * | ***Gymnostyles stolonifera*** | | * | |
| *Carrichtera annua* | | | * | *Heliotropium* ramossissimum | * | * | |
| ***Castanea sativa*** | | * | | *Hirschfeldia incana* | * | * | |
| *Castellia tuberculosa* | | | * | *Hyparrhenia hirta* | * | * | * |
| *Cenchrus ciliaris* | * | * | * | *Inula viscosa* | * | | |
| *Centaurea melitensis* | * | * | * | *Kickxia scoparia* | | | * |
| *Centranthus calcitrapae* | | | * | *Kleinia neriifolia* | * | * | * |
| *Cerastium glomeratum* | | * | | *Lactuca serriola* | * | | |
| *Ceropegia fusca* | * | | | *Lamarckia aurea* | | | * |
| *Chamaecytisus proliferus* | * | * | * | ***Lantana camara*** | | * | |
| *Cheilanthes pulchella* | | * | * | *Launaea arborescens* | * | * | * |
| *Chenopodium murale* | * | * | * | | | | |
| *Lavandula canariensis* | * | * | * | *Rumex acetosella* | | * | |
| *Leontodon taraxacoides* | * | * | * | *Rumex bucephalophorus* | | * | |
| *Limonium pectinatum* | * | | | *Rumex lunaria* | | * | * |
| *Lobularia canariensis* | * | * | | *Rumex maderensis* | | * | |
| *Logfia gallica* | | * | * | *Rumex vesicarius* | * | * | * |
| *Lolium canariense* | | | * | *Salvia canariensis* | | * | |
| *Lolium rigidum* | | | * | *Sanguisorba minor* | * | * | |
| *Lotus campylocladus* | * | | * | *Schizogyne sericea* | * | | * |
| *Lotus sessilifolius* | * | | * | *Scilla haemorrhoidalis* | | * | * |
| ***Lycopersicon esculentum*** | | | * | *Scorpiurus muricatus* | * | | |
| *Malva parviflora* | * | * | * | *Scrophularia glabrata* | * | | * |
| *Marrubium vulgare* | | * | | *Senecio coronopifolius* | * | | |
| *Medicago arabica* | | * | | *Senecio vulgaris* | * | * | |
| *Medicago italica* | | | * | *Sideritis cretica* | | * | |
| *Medicago minima* | * | | | *Sideritis oroteneriffae* | * | * | |
| *Medicago polymorpha* | * | * | * | *Silene gallica* | * | * | |
| *Melilotus* sp. | | * | | *Silene vulgaris* | * | * | * |
| ***Mercurialis annua*** | * | * | | *Sisymbrium erysimoides* | * | | |
| ***Mesembryanthemum crystallinum*** | * | * | * | *Sisymbrium irio* | | * | |
| ***Mesembryanthemum nodiflorum*** | * | * | * | *Sisymbrium orientale* | | * | |
| *Micromeria hyssopifolia* | * | * | * | *Sisymbrium* sp. | | | * |
| *Micromeria varia* | * | | | *Sonchus acaulis* | | * | |
| *Misopates orontium* | * | * | * | *Sonchus asper* | | * | |

**Table 3** continued

| Species name | Road | | | Species name | Road | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | 1 | 2 | 3 |
| *Muscari comosum* | * | | | *Sonchus canariensis* | | | * |
| *Neotinea maculata* | | * | | *Sonchus oleraceus* | * | * | * |
| *Nepeta teydea* | * | * | | *Sonchus tenerrimus* | * | * | * |
| ***Nicotiana glauca*** | * | * | * | *Spartocytisus supranubius* | * | * | * |
| *Notholaena marantae* | | | * | *Spergularia fallax* | * | * | * |
| *Notoceras bicorne* | | * | * | *Stachys arvensis* | * | | |
| *Olea cerasiformis* | | | * | *Stellaria media* | | * | |
| *Ononis dentata* | | | * | *Stipa capensis* | * | | * |
| ***Opuntia cilindrica*** | | * | | *Tinguarra montana* | | * | |
| ***Opuntia dillenii*** | * | | * | *Tolpis barbata* | * | | * |
| ***Opuntia ficus-indica*** | * | * | * | *Tolpis laciniata* | | | * |
| ***Oxalis pes-caprae*** | * | * | | *Tolpis webbii* | * | | |
| *Pallenis spinosa* | * | | | *Torilis* sp. | | * | * |
| *Pancratium canariense* | * | | | *Tragopogon porrifolius* | * | * | |
| *Parietaria debilis* | * | * | * | *Trifolium angustifolium* | | * | |
| *Patellifolia patellaris* | * | * | * | *Trifolium arvense* | * | * | * |
| ***Pennisetum setaceum*** | * | * | | *Trifolium campestre* | | | * |
| *Periploca laevigata* | * | * | * | *Trifolium glomeratum* | | | * |
| *Phagnalon saxatile* | * | * | | *Trifolium scabrum* | | | * |
| *Pimpinella cumbrae* | * | | | *Trifolium* sp. | | * | |
| *Pinus canariensis* | * | * | * | *Trifolium stellatum* | | * | |
| *Piptatherum coerulescens* | * | * | * | ***Tropaeolum majus*** | | * | |
| *Piptatherum miliaceum* | * | * | * | *Tuberaria guttata* | * | | * |
| *Plantago afra* | * | | * | *Umbilicus gaditanus* | | | * |
| *Plantago amplexicaulis* | | | * | *Urospermum picroides* | * | * | * |
| *Plantago lagopus* | * | | | *Vicia cirrhosa* | | | * |
| *Plocama pendula* | * | * | * | *Vicia disperma* | * | | |
| *Policarpon tetraphyllum* | | * | | *Vicia lutea* | | * | |
| *Polycarpaea divaricata* | * | * | * | *Vicia* sp. | * | | |
| *Polycarpaea nivea* | * | | | ***Vitis vinifera*** | * | * | * |
| *Polycarpaea tenuis* | * | | * | *Volutaria canariensis* | * | * | * |
| ***Prunus dulcis*** | | | * | *Vulpia myuros* | * | * | * |
| *Pterocephalus lasiospermus* | * | * | * | *Wahlenbergia lobelioides* | * | * | * |
| *Ranunculus cortusifolius* | | | * | ***Washingtonia filifera*** | | * | |
| ***Ricinus communis*** | | * | | *Zygophyllum fontanesii* | * | | |
| *Rubia fruticosa* | | | * | | | | |

Bold letters indicate that the species is considered exotic (Izquierdo et al. 2004)

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