Socioeconomics and temperature anomalies: drivers of introduced and native plant species composition and richness in the Canary Islands (1940-2010)

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Abstract

Background: Islands are particularly sensitive to biological invasions. The arrival of humans with their cohort of accompanying species has been cited as one of the primary causes for ecosystem change.
Question: The introduction of these non-native species has been largely responsible for the tragic disappearance of native island biota and the dismantling of island ecosystems worldwide.
Methods: Ordination analyses to determined changes in native and exotic species composition along the period analysed.
Results: Mean temperature on the island of Tenerife has increased by around 0.6 ºC in the last 70 years, while minimum temperature has risen by approx. 1.5 ºC. Despite overall warming being milder than in the northern hemisphere, owing to the more sensitive biota these changes may have a strong influence on biodiversity. In addition, socioeconomic indicators have also changed significantly over the last 70 years with consequences for nature conservation. In this study, we analyse which parameters are best placed to explain the increase of introduced species, not just in terms of species richness, but also in species composition. We restrict the study to thermophile invasive and introduced species, as they respond more rapidly to climate change.
Conclusions: We found that socioeconomic aspects of development are important elements that relate closely to the increase in richness and changes in species composition for native as well for introduced species. In the case of invasive species richness, the average minimum temperature is the most closely related variable. However, mean temperature anomalies did not reveal any relationship with these changes.
Key words: Canary Islands, CCA, DCA, correlation, global warming, introduced species

Aspectos socioeconómicos y anomalías de temperatura: responsables del incremento del número de especies introducidas en las Islas Canarias (1940-2010)

Resumen

Antecedentes: Las islas son particularmente sensibles a las invasiones. La llegada de humanos con sus especies acompañantes son una de las primeras causas de cambios ecosistémicos.
Pregunta: ¿Se relacionan las especies introducidas con la desaparición de especies a lo largo de los ecosistemas insulares del planeta?
Métodos: Análisis de ordenación para determinar cambios de riqueza de especies nativas e introducidas a lo largo del periodo.
Resultados: La temperatura media de la isla de Tenerife se ha incrementado en 0.6 ºC en los últimos 70 años, mientras que la media de las temperaturas mínimas en aproximadamente 1.5 ºC. A pesar de que el calentamiento es inferior al sufrido en el hemisferio norte, la mayor sensibilidad de la especies a estos cambios puede provocar negativos efectos en la diversidad. Por otro lado, los indicadores socieconómicos también han cambiado en los últimos 70 años con importantes cambios para el medio natural. En este trabajo analizamos que parámetros se relacionan mejor con el incremento de especies introducidas, no sólo en términos de riqueza, sino también de composición de especies. Restringimos el estudio a especies introducidas e invasoras termófilas.
Conclusiones: Hemos encontrado que los parámetros indicadores de desarrollo son importante elementos relacionados con el cambio en riqueza y composición de especies tanto naturales como introducidas. En el caso de la riqueza de invasoras, la media de la temperatura media aparece como variable relacionada. Aunque no hemos encontrado relaciones de temperaturas medias (sólo con la media de las mínimas) con las variaciones en especies introducidas e invasoras.
Palabras clave: calentamiento global, CCA, DCA, correlación, especies introducidas, Islas Canarias

Author Contributions
José Ramón Arévalo conceived, designed the experiments, analyzed the data and wrote the paper.
José Luis Martín conceived and designed the experiments, selected the data, prepared the data base and reviewed drafts of the paper.
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Introduction

Invasive species have been considered one of the main causes of habitat degradation (Gurevitch & Padilla 2004) and highly related to global change and globalization (Kaluza *et al*. 2010). The result is an increase in the number of these species in different ecosystem around the planet, reaching areas that were almost inaccessible a few decades ago and even threatening protected plant communities (i.e. high altitudinal areas or riparian areas; Pauchard *et al*. 2009, Alexander *et al*. 2011, Aguiar & Ferreira 2013). Specific elements of globalization that explain the spread of invasive species around the planet are global change (global warming, nitrogen deposition or habitat fragmentation; Dukes & Mooney 1999) and also socieconomic ones, such as gross domestic product (GDP; Sharma *et al*. 2010), transport (Westphal *et al*. 2008) or tourism (Sutherst 2000) among others. Ultimately, the economic (Pimentel *et al*. 2005), health (Levine & D'Antonio 2003), and ecological (Lockwood & McKinney 2001, Reaser *et al*. 2007) consequences can be substantial. For some areas, rapid economic development has accelerated biological invasions (Lin *et al*. 2007). Hulme (2009) argues that the best strategy for invasive species control is to regulate the mechanisms that govern globalization rather than direct species-by-species management. Globalization as a recent phenomenon has been one of the most substantial drivers behind the homogenization of insular biotas (Florencio *et al*. 2013) related to worldwide alien species expansion (Levine & d'Antonio 2003, Westphal *et al*. 2008, Pyšek *et al*. 2010).

Islands are particularly sensitive to biological invasions (Hulme 2004, Silva & Smith 2004). Humans' arrival with their accompanying species has been cited as the primary cause for ecosystems change (Atkinson & Cameron 1993). The tragic disappearance of native island biota and dismantling of island ecosystems worldwide have been primarily caused by the introduction of non-native species (Donlan & Wilcox 2008, Kueffer *et al*. 2010). In addition, mean temperature on the island of Tenerife has increased by around 0.6 degrees, while this increase has been almost 1.5 degrees in the case of minimum temperature (mean of nocturnal minima) in the last 70 years (Martín *et al*. 2012). The overall warming is milder than in the northern hemisphere, however, the more sensitive biota means that small changes can have a strong influence on community species composition.

As islands are considered more vulnerable to invasions, we analyse which parameters are best placed to explain the increase in introduced species, in terms of species richness and composition. We restricted the study to thermophile invasive and non-invasive introduced species, as they respond faster and are more closely related to climate change. We selected common socioeconomic parameters related to development, and also temperature anomalies detected in the archipelago. We analysed data going back to the 40s, as we have reliable information about these variables from this period onwards. The main hypotheses to test are whether mean and minimum temperature anomalies are the best variables to explain changes in species composition and richness of introduced and invasive species or whether other socioeconomic variables are more closely related to these changes. Base in the results we will suggest management proposals.

We consider that an interdisciplinary work involving economy, climate and ecology is required to understand the roles all these variable play in biological invasion and to provide a way forward in our understanding of the entire scenario of the process.

Material and methods

Study site. The Canary Island Archipelago is composed of seven islands, 100 km off Northwest Africa (28º N, 16º W). The islands exhibit a broad spectrum of habitats with marked altitudinal belts and islands of varied sizes. The highest island, Tenerife reaches 3,718 m a.s.l and the lowest, Lanzarote, 800 m. Tenerife also occupies the largest (2.059 km^2) and Hierro the smallest (273 km^2) surface areas. The lower elevations exhibit a Mediterranean type climate, with cool, mild winters and warm, dry summers (< 300 mm of ppt/year). Mid-altitudes experience persistent cloud cover that maintains cool and humid summers, and colder winters with increased precipitation (>700 mm/year). Over 1,500 m a.s.l. the climate is more continental and arid, with cold winters and very hot summers (< 500 mm ppt/year). Island altitude has substantial influence on local climate, but in general, the Canary Islands are considered temperate-subtropical.

The islands are a densely populated territory with more than 2 million residents, a busy tourist destination, and well connected to transport routes for trade in goods and services. Furthermore, the Canary Islands have been identified as a location subjected to the consequences of climate change (Sperling *et al*. 2004, del Arco 2008, Brito 2008, Martín *et al*. 2012). The region's biodiversity is characterized by its uniqueness with 3,857 endemic species among the 2,554 terrestrial plant taxa registered in the official biodiversity data bank of the Canarian Government (Arechavaleta-Hernández *et al*. 2010). However, 1,567 of these species have been introduced into the archipelago, reducing native flora endemicity (in percentages with respect the total) from fifty percent of the biota a few centuries ago to one third of the species today.

The geographical position of Canary Islands is commercially influenced by Europe, Africa, and America, climatically by the temperate and tropical bands to the north and south, and ecologically by continental and oceanic systems to the east and west, respectively. This makes the islands particularly suitable for studying the influences of climate and global interconnectedness in island biological composition.

Biotic information. Following the criteria employed by the Canary Islands' biodiversity databank (Arechavaleta-Hernández *et al*. 2010), wild plant species (it does not include cultivate species, only does that dispersed without human assistance) were classified into the following three categories: native species, invasive and non-invasive introduced species. Native are endemic species of the archipelago and non-endemic but considered that reached the archipelago naturally (Arechavaleta-Hernández *et al*. 2010). From the last two groups, we selected only the thermophile species (defined as species whose original range of distribution is in warmer climates than the Canary Islands; Köppen & Geiger 1928), which tend to be the most sensitive species to climate change.

The method of assignment of the species to each decade has some limitations in as much as some of the plants could have arrived much earlier in the archipelago than the date they were detected in the field. Also, the species catalogue is base in published lists of species, and it is not taking into account the evolution of the species along the decades, they can be change from introduce to invasive (Dietz & Edwards 2006), but the period of time is short in order to consider important changes. In spite of that, the large amount of data allows the analysis and identification of relevant general patterns. We should consider this study as an exploratory analysis of relationships about this information and the variables used in the analyses, and that we consider is consistent with changes in the species composition.

Native taxa in the Canary Islands are defined as species that arrived via dispersal means not associated with anthropogenic activity (some of them have been able to evolve in situ and become endemic), such as species with restricted distribution, limited to one of the natural Canary Island habitats. If the accidental or deliberate introduction of a species into the Canary Islands is known, but the species has not extended its range throughout the islands to cause significant changes to ecosystems and native species, it is considered introduced non-invasive. Invasive species are characterized as being exotic species established in natural or semi-natural habitats, causing significant changes in ecological systems and native biota, with the potential for permanent disruption of the ecological continuity of the local environment. The total number of species included in the study were 41 invasive (hereafter invasive), 189 introduced non-invasive (hereafter introduced) and 477 native endemic (hereafter native).

All species were assigned to an appearance decade ranging from 1940 to 2010 (many of them were cited earlier, but these have been assigned to the 1940s' decade), on the basis of collection dates cited in bibliographical records. This method has the disadvantage of being subject to an unknown delay after the actual arrival and appearance date of the species, and subsequent report and publication date. Consequently, the number of species reported in our study for the last decade is likely to be less than the actual number of species present on the islands. Information on the presence of the species is accumulative, meaning that if the species is present in one year, it is assumed present in subsequent decades unless extinction or eradication has been documented.

Socioeconomic and climatic information. The majority of information has been extracted from the Canarian Institute of Statistics (ISTAC; http://www.gobiernodecanarias.org/istac), and the information has been grouped in decades to prepare the information for comparison with the biotic information.

The variables selected were number of tourists (before 1960 the information was extracted from Anonymous 1997; hereafter TOU), gross domestic product (before 1950 the information was obtained from Díaz 2003; hereafter GDP) and population density (hereafter POP). We took the value of the variables at the end of the decade, so 1940 took variable values from December 1949.

For mean temperature anomalies (hereafter TEM) and minimum temperature anomalies (hereafter mTEM), we used the information provided by Martín *et al*. (2012), using the average temperature anomalies for each decade. We consider that the average of the decade is more indicative than the value of the last year of the decade, in order to avoid the natural variability of the climatic information.

Statistical analyses. Ordination techniques help to explain community variation (Gauch 1982), and they can be used to evaluate trends over time as well as in space (Franklin *et al*., 1993, ter Braak & Šmilauer 1998). We used Detrended Correspondence Analysis (DCA; Hill & Gauch 1980, using CANOCO; ter Braak & Šmilauer 1998) to examine how species composition changed over time. Analyses were based on presence, and we analyzed the invasive, introduced and native species separately.

As a technique of direct gradient analysis, we used Canonical Correspondence Analysis (CCA; Hill & Gauch 1980) in CANOCO (ter Braak & Šmilauer 1998) to examine how species composition in different decades changed as a function of the independent matrix of information (TOU, GDP, POP, TEM and mTEM). We used a forward selection procedure to remove the variables that did not support a significant portion of the inertia reported by the analysis with a Monte Carlo permutation test (499 iterations for a $p < 0.05$) in CANOCO. Using this method we were able to estimate directly which variables were important to determine changes in species composition over these decades. Again, we proceeded by analyzing separately invasive, introduced and native species.

We correlated the site scores of the three DCA axis I and II with the five variables: TOU, GDP, POP, TEM and mTEM (using the Pearson correlation coefficient, for $p < 0.05$ and $n = 7$). Additionally, species richness of invasive, native and introduced was correlated with the indicated variables. For both analyses, we applied the Holm's procedure for multiple testing.

Basic statistical methods followed those of Legendre & Legendre (1998) and were implemented using the SPSS statistical package (SPSS 1997).

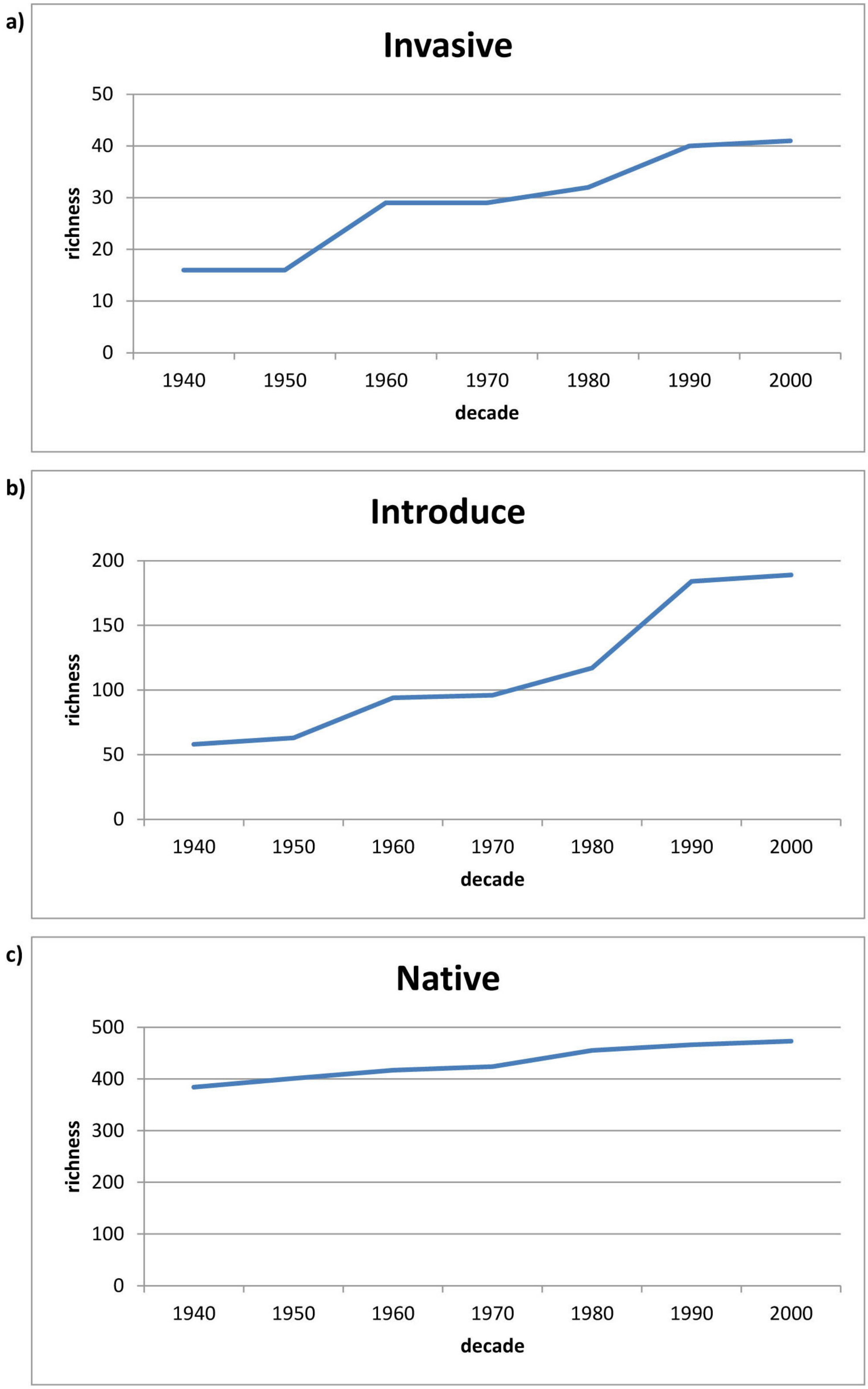
Results

Values for richness of invasive, introduced and native species have been increasing over the last decades. This increase has been faster in the case of introduced (356 %) species followed by invasive (256 %) and finally endemic native species (130 %). Regarding invasive species, the fastest increase in richness is found between 1950 and1960; while for introduced ones the greatest rise was between 1980 and1990. For native endemic, the rate of increase in richness appears more continuous (Figure 1); Tables 1, 2 and S1 (the last one as electronic supplementary material format) provide a list of the species included in the three groups: invasive, introduced and native species.

The information for TOU, GDP, POP, TEM, mTEM is presented in Table 3. The dramatic increase in GDP is particularly important from the decades 1940 to 1960. This was the period in which the Spanish dictatorship began to open up the economy ending decades of autarchy. This was followed by the tourist boom that started in the 60s. While the main increase in tourist numbers appeared in the 80s, the largest population increase (25 %) was in the decade of the 90s. With regard to temperature anomalies, the greatest rise in temperature appears in the last decade, while a constant but almost insignificant increase was the common pattern in the previous decades. The change in average temperature is more relevant in the case of minimum temperatures.

The analysis of species composition for invasive species revealed that a few of the most ag-

Figure 1. Species richness over decades for **a)** invasive thermophile . **b)** introduced thermophile and **c)** native.



gressive ones were present during the first decade of this study such as *Opuntia maxima*, *Opuntia dillenii*, *Agave americana*, *Acacia farnesiana* or *Arundo donax*; whereas others arrived in the last few decades like *Crassula multicava* and *Chasmanthe aethiopica*. The greatest change in species composition occurred between 1950 and 1960 (Figure 2). In the case of introduced

Table 1. Pooled list of invasive thermophilic species for the decade in which were cited for the first time as indicated in Arechevaleta *et al*. (2010).

Native endemic species		**Decade**
Acacia farnesiana	(L.) Willd.	1940
Agave americana	L.	1940
Ageratina adenophora	(Spreng.) R. M. King & H. Rob.	1940
Ageratina riparia	(Regel) R. M. King & H. Rob.	1940
Anredera cordifolia	(Ten.) Steenis	1940
Argemone mexicana	L.	1940
Arundo donax	L.	1940
Datura innoxia	Mill.	1940
Datura stramonium	L.	1940
Eleusine indica	(L.) Gaertn.	1940
Lantana camara	L.	1940
Melinis repens	(Willd.) Zizka	1940
Nicotiana glauca	R. C. Graham	1940
Nicotiana paniculata	L.	1940
Opuntia maxima	Mill.	1940
Tropaeolum majus	L.	1940
Acacia cyanophylla	Lindl.	1960
Cardiospermum grandiflorum	Sw.	1960
Cyrtomium falcatum	(L.) C. Presl	1960
Ipomoea cairica	(L.) Sweet	1960
Mirabilis jalapa	L.	1960
Nassella neesiana	(Trin. & Rupr.) Barkworth	1960
Neurada procumbens	L.	1960
Opuntia dillenii	(Ker-Gawl.) Haw.	1960
Opuntia robusta	H.L. Wendland	1960
Opuntia tomentosa	Salm-Dyck	1960
Opuntia vulgaris	Mill.	1960
Pennisetum setaceum	(Forssk.) Chiov.	1960
Tradescantia fluminensis	Vell.	1960
Acacia dealbata	Link	1980
Caesalpinia spinosa	(Molina) Kuntze	1980
Ipomoea indica	(Burm. f.) Merr.	1980
Austrocylindropuntia exaltata	(Berg) Backeb.	1990
Furcraea foetida	(L.) Haw.	1990
Hylocereus undatus	(Haw.) Britton & Rose	1990
Ipomoea purpurea	(L.) Roth	1990
Kikoyuochloa clandestinum	(Vhiov.) H.Scholz	1990
Leucaena leucocephala	(Lam.) de Wit	1990
Maireana brevifolia	(R. Br.) P.G. Wilson	1990
Wigandia caracasana	"Humb., Bonpl. & Kunth "	1990
Atriplex semilunaris	Aellen	2000

species, the DCA revealed a major change between 1950 and 1960, but also (base in DCA axis II) a change between 1990 and 2000. As for early arrivals, we found *Bidens pilosa* or *Solanum jasminoides*, and for late arrivals we have species like *Nicotiana glutinosa* or *Portulaca nicaraguensis* (Figure 3). Finally, for native species (Figure 4), only the decade coordinates are indicated (more than 500 species cannot be plotted), revealing a substantial change in species composition in the 1970s and 80s, possibly due to the foundation of the Faculty of Biology of the University of La Laguna (although this information has been not analyzed it agree with an increased with the number of publications that appeared in that decade).

When we correlated the decade coordinates of DCA- Axis I with the socioeconomic and temperature variables, the analysis revealed that native species are closely related to socioeconomic parameters over these decades. Additionally, with lower correlation strength, introduced species

Table 2. Pooled list of introduce thermophilic species for the decade in which were cited for the first time as indicated in Arechevaleta *et al.* (2010).

Introduce thermophilic species		Decade
Abutilon grandifolium	(Willd.) Sweet	1940
Acacia farnesiana	(L.) Willd.	1940
Achyranthes aspera	L.	1940
Agave americana	L.	1940
Ageratina adenophora	(Spreng.) R. M. King & H. Rob.	1940
Ageratina riparia	(Regel) R. M. King & H. Rob.	1940
Alternanthera caracasana	"Humb., Bonpl. & Kunth"	1940
Amaranthus deflexus	L.	1940
Amaranthus hybridus	L.	1940
Amaranthus lividus	L.	1940
Amaranthus muricatus	(Moq.) Hieron.	1940
Amaranthus viridis	L.	1940
Anredera cordifolia	(Ten.) Steenis	1940
Argemone mexicana	L.	1940
Arundo donax	L.	1940
Asclepias curassavica	L.	1940
Atriplex semibaccata	R. Br.	1940
Bidens pilosa	L.	1940
Caesalpinia sepiaria	Roxb.	1940
Calceolaria tripartita	Ruiz & Pav.	1940
Carthamus tinctorius	L.	1940
Ceratochloa catartica	(Vall) Herter	1940
Chamaesyce prostrata	(Aiton) Small	1940
Chenopodium ambrosioides	L.	1940
Colocasia esculenta	(L.) Schott	1940
Commelina benghalensis	L.	1940
Commelina diffusa	Burm. f.	1940
Conyza bonariensis	(L.) Cronquist	1940
Conyza floribunda	"Humb., Bonpl. & Kunth"	1940
Conyza gouani	(L.) Willd.	1940
Cyperus rotundus	L.	1940
Datura innoxia	Mill.	1940
Datura stramonium	L.	1940
Einadia nutans	(R. Br.) A. J. Scott	1940
Eleusine indica	(L.) Gaertn.	1940
Hunnemannia fumariifolia	Sweet	1940
Lantana camara	L.	1940
Lepidium bonariense	L.	1940
Lepidium sativum	L.	1940
Lycopersicon esculentum	Mill.	1940
Malvastrum coromandelianum	(L.) Garcke	1940
Melianthus comosus	Vahl	1940
Melinis repens	(Willd.) Zizka	1940
Myrtus communis	L.	1940
Nicandra physalodes	(L.) Gaertn.	1940
Nicotiana alata	Link & Otto	1940
Nicotiana glauca	R. C. Graham	1940
Nicotiana paniculata	L.	1940
Nicotiana tabacum	L.	1940
Oenothera rosea	L`Hér. ex Aiton	1940
Opuntia maxima	Mill.	1940
Paspalum paspalodes	(Michx.) Scribn.	1940
Pennisetum villosum	R. Br. ex Fresen.	1940
Phylla nodiflora	(L.) E.L. Greene	1940
Physalis peruviana	L.	1940
Ricinus communis	L.	1940
Salvia coccinea	Juss. ex Murray	1940
Schinus molle	L.	1940
Scorpiurus muricatus	L.	1940
Senna bicapsularis	(L.) Roxb.	1940
Senna occidentalis	(L.) Link	1940
Sida acuta	Burm. f.	1940
Sida rhombifolia	L.	1940
Sigesbeckia orientalis	L.	1940
Solanum pseudocapsicum	L.	1940
Solanum robustum	H.L. Wendl.	1940
Soliva stolonifera	(Brot.) Sweet	1940
Sorghum halepense	(L.) Pers.	1940
Tagetes minuta	L.	1940
Tropaeolum majus	L.	1940
Turbina corymbosa	(L.) Raf.	1940
Verbena bonariensis	L.	1940
Waltheria indica	L.	1940
Xanthium spinosum	L.	1940
Casuarina equisetifolia	L.	1950
Cyperus involucratus	Rottb.	1950
Opuntia tuna	(L.) Mill.	1950
Salvia leucantha	Cav.	1950
Solanum marginatum	L. f.	1950
Acacia cyanophylla	Lindl.	1960
Adiantum raddianum	C. Presl	1960
Agave sisalana	(Engelm.) Perr.	1960
Amaranthus quitensis	"Humb., Bonpl. & Kunth"	1960
Bidens aurea	(Dryand.) Sherff	1960
Cardiospermum grandiflorum	Sw.	1960
Chenopodium multifidum	L.	1960
Ciclospermum leptophyllum	(Pers.) Sprague	1960
Cotula australis	(Siebold ex Spreng.) Hook. f.	1960
Cucurbita pepo	L.	1960
Cyrtomium falcatum	(L.) C. Presl	1960
Erigeron karvinskianus	DC.	1960
Eucalyptus camaldulensis	Dehnh.	1960
Galinsoga parviflora	Cav.	1960
Galinsoga quadriradiata	Ruiz & Pav.	1960
Guizotia abyssinica	(L. f.) Cass.	1960
Ipomoea cairica	(L.) Sweet	1960
Megathyrsus maximum	(Jacq.) B.K. Simon & S.W.L. Jacobs	1960
Melia azedarach	L.	1960
Mirabilis jalapa	L.	1960
Nassella neesiana	(Trin. & Rupr.) Barkworth	1960
Neurada procumbens	L.	1960
Oenothera jamesii	Torrey & A. Gray	1960
Opuntia dillenii	(Ker-Gawl.) Haw.	1960
Opuntia robusta	H.L. Wendland	1960
Opuntia tomentosa	Salm-Dyck	1960
Opuntia vulgaris	Mill.	1960
Oryza sativa	L.	1960
Oxalis corymbosa	DC.	1960
Oxalis latifolia	Kunth	1960
Pennisetum purpureum	Schumach.	1960
Pennisetum setaceum	(Forssk.) Chiov.	1960
Petunia parviflora	Juss.	1960
Phaseolus vulgaris	L.	1960
Salpichroa origanifolia	(Lam.) Baill.	1960
Sechium edule	(Jacq.) Sw.	1960
Sedum dendroideum	(Moq. & Sessé) ex DC.	1960

Table 2. Continuation.

Introduce thermophilic species		Decade
Selaginella kraussiana	(Kunze) A. Braun	1960
Solanum jasminoides	Paxton	1960
Stenotaphrum secundatum	(Walter) Kuntze	1960
Symphyotrichum squamatum	(Spreng.) G.L. Nesom	1960
Tagetes patula	L.	1960
Tradescantia fluminensis	Vell.	1960
Zebrina pendula	Schnizl.	1960
Ageratum houstonianum	Mill.	1970
Pennisetum thunbergii	Kunth	1970
Acacia dealbata	Link	1980
Adiantum hispidulum	Sw.	1980
Azolla filiculoides	Lam.	1980
Bougainvillea glabra	Choisy	1980
Bryophyllum delagoÎnse	(Eckl. & Zeyh.) Schinz	1980
Bryophyllum pinnatum	(Lam.) Oken	1980
Caesalpinia spinosa	(Molina) Kuntze	1980
Canna indica	L.	1980
Casuarina cunninghamiana	Miq.	1980
Catharanthus roseus	(L.) Don	1980
Commicarpus helenae	(Schult.) Meikle	1980
Eleusine tristachya	(Lam.) Lam.	1980
Fuchsia boliviana	Carrière	1980
Graptopetalum paraguayense	(N. E. Br.) E. Walther	1980
Hyparrhenia arrhenobasis	(Hochst. ex Steud.) Stapf	1980
Ipomoea indica	(Burm. f.) Merr.	1980
Iris albicans	Lange	1980
Leonotis nepetifolia	(L.) R. Br. in Aiton	1980
Maurandya scandens	(Cav.) Pers.	1980
Paspalum dilatatum	Poir.	1980
Paspalum urvillei	Steud.	1980
Pisum sativum	L.	1980
Senna didymobotrya	(Fresen.) H. S. Irwin & Barneby	1980
Setcreasea pallida	Rose	1980
Agave ferox	C. Koch	1990
Agave fourcroydes	Lem.	1990
Alpinia zerumbet	(Pers.) Burtt & R. M. Sm.	1990
Amaranthus caudatus	L.	1990
Amaranthus cruentus	L.	1990
Amaranthus standleyanus	Parodi ex Covas	1990
Atriplex suberecta	Verd.	1990
Austrocylindropuntia cylindrica	(Lam.) Backeb.	1990
Austrocylindropuntia exaltata	(Berg) Backeb.	1990
Bambusa vulgaris	Schrad.	1990
Brugmansia suaveolens	(Willd.) Bercht. & J. Presl	1990
Bryophyllum daigremontianum	(Raym.-Hamet & Perr.)	1990
Bryophyllum proliferum	Bowie ex Curtis	1990
Calliandra tweedii	Benth.	1990
Calotropis procera	(Aiton) W. T. Aiton	1990
Cicer arietinum	L.	1990
Coffea arabica	L.	1990
Conyza sumatrensis	(Retz.) E.Walker	1990
Corchorus depressus	(L.) Stocks	1990
Cortaderia selloana	(Schult. & Schult. f.) Asch. & Graebn.	1990
Cyperus esculentus	L.	1990
Desmanthus virgatus	(L.) Willd.	1990
Euphorbia milii	Des Moul. ex Boiss.	1990
Fuchsia coccinea	Aiton	1990
Furcraea foetida	(L.) Haw.	1990
Gossypium herbaceum	L.	1990
Heliotropium curassavicum	L.	1990
Hylocereus undatus	(Haw.) Britton & Rose	1990
Hyparrhenia rufa	(Nees) Stapf in Prain	1990
Impatiens olivieri	C. H. Wright ex W. Watson	1990
Impatiens walleriana	Hook. f.	1990
Imperata cylindrica	(L.) Rauschel	1990
Ipomoea batatas	(L.) Lam.	1990
Ipomoea hederacea	Jacq.	1990
Ipomoea pes-caprae	(L.) Sweet	1990
Ipomoea purpurea	(L.) Roth	1990
Kikoyuochloa clandestinum	(Vhiov.) H.Scholz	1990
Leucaena leucocephala	(Lam.) de Wit	1990
Lippia canescens	"Humb., Bonpl. & Kunth"	1990
Maireana brevifolia	(R. Br.) P.G. Wilson	1990
Montanoa bipinnatifida	(Kunth) C. Koch	1990
Musa acuminata	Colla	1990
Nephrolepis exaltata	(L.) Schott	1990
Oenothera striata	Ledeb. ex Link	1990
Oplismenus hirtellus	(L.) P. Beauv.	1990
Parkinsonia aculeata	L.	1990
Paspalum distichum	L.	1990
Passiflora suberosa	L.	1990
Phaedranthus buccinatorius	(DC.) Miers	1990
Phyllanthus tenellus	Roxb.	1990
Pistia stratiotes	L.	1990
Pteris cretica	L.	1990
Pteris multifida	Poir.	1990
Pyrostegia venusta	(Ker-Gawl.) Miers	1990
Saccharum officinarum	L.	1990
Salvinia natans	(L.) All.	1990
Sansevieria trifasciata	Prain	1990
Sedum mexicanum	Britton	1990
Senna corymbosa	(Lam.) H. S. Irwin & Barneby	1990
Senna multiglandulosa	(Jacq.) H. S. Irwin & Barneby	1990
Sesuvium portulacastrum	(L.) L.	1990
Sidastrum paniculatum	(L.) Fryxell	1990
Simmondsia chinensis	(Link) C. K. Schneid.	1990
Solanum giganteum	Jacq.	1990
Solanum gracile	Otto	1990
Solanum mauritianum	Scop.	1990
Solanum microcarpum	(Pers.) Vahl	1990
Solanum nodiflorum	Jacq.	1990
Solanum tuberosum	L.	1990
Tithonia diversifolia	(Hemsl.) A. Gray	1990
Tradescantia blossfeldiana	Mildbr.	1990
Tripleurospermum inodorum	(L.) Sch. Bip.	1990
Wigandia caracasana	"Humb., Bonpl. & Kunth"	1990
Xerochrysum bracteatum	(Vent.) Tzvelec	1990
Zea mays	L.	1990
Atriplex semilunaris	Aellen	2000
Gnaphalium antillanum	Urb.	2000
Nicotiana glutinosa	L.	2000
Portulaca nicaraguensis	(Danin & H. G. Baker) Danin	2000
Portulaca papillato-stellulata	(Danin & H. G. Baker) Danin	2000
Suaeda fruticosa	Forssk. ex J. F. Gmel.	2000

Table S1. Pooled list of native endemic species for the decade in which were cited for the first time as indicated in Arechevaleta *et al*. (2010).

Native endemic species		Decade	Native endemic species		Decade
Andryala pinnatifida	Aiton	1940	*Reichardia ligulata*	(Vent.) G. Kunkel & Sunding	1940
Andryala webbii	Sch. Bip. ex Christ	1940	*Schizogyne glaberrima*	DC.	1940
Argyranthemum adauctum	(Link) Humphries	1940	*Senecio bollei*	Sunding & G. Kunkel	1940
Argyranthemum broussonetii	(Pers.) Humphries	1940	*Senecio hermosae*	Pit.	1940
Argyranthemum callichrysum	(Svent.) Humphries	1940	*Senecio palmensis*	(C. Sm. in Buch) Link	1940
Argyranthemum coronopifolium	(Willd.) Humphries	1940	*Senecio teneriffae*	Sch. Bip.	1940
Argyranthemum escarrei	(Svent.) Humphries	1950	*Sonchus acaulis*	Dum. Cours.	1940
Argyranthemum filifolium	(Sch. Bip.) Humphries	1940	*Sonchus bornmuelleri*	Pit.	1960
Argyranthemum foeniculaceum	(Willd.) Webb ex Sch. Bip.	1940	*Sonchus brachylobus*	Webb & Berthel.	1940
Argyranthemum frutescens	(L.) Sch. Bip.	1940	*Sonchus canariensis*	(Sch. Bip.) Boulos	1940
Argyranthemum gracile	Sch. Bip.	1940	*Sonchus congestus*	Willd.	1940
Argyranthemum haouarytheum	Humphries & Bramwell	1940	*Sonchus fauces-orci*	Knoche	1940
Argyranthemum hierrense	Humphries	1940	*Sonchus gandogeri*	Pit.	1940
Argyranthemum lemsii	Humphries	1940	*Sonchus gomerensis*	Boulos	1950
Argyranthemum lidii	Humphries	1940	*Sonchus gummifer*	Link	1940
Argyranthemum maderense	(D. Don) Humphries	1940	*Sonchus hierrensis*	(Pit.) Boulos	1940
Argyranthemum sundingii	L. Borgen	1990	*Sonchus lidii*	Boulos	1940
Argyranthemum sventenii	Humphries & Aldridge	1980	*Sonchus ortunoi*	Svent.	1950
Argyranthemum tenerifae	Humphries	1940	*Sonchus palmensis*	(Sch. Bip.) Boulos	1940
Argyranthemum webbii	Sch. Bip.	1940	*Sonchus pitardii*	Boulos	1960
Argyranthemum winteri	(Svent.) Humphries	1940	*Sonchus radicatus*	Aiton	1940
Artemisia ramosa	C. Sm. in Buch	1940	*Sonchus tectifolius*	Svent.	1960
Artemisia thuscula	Cav.	1940	*Sonchus tuberifer*	Svent.	1940
Asteriscus intermedius	(DC.) Pit. & Proust	1940	*Sonchus wildpretii*	U. Reifenberger & A. Reifenberger	1980
Asteriscus sericeus	(L. f.) DC.	1940			
Atractylis arbuscula	Svent. & Michaelis	1940	*Stemmacantha cynaroides*	(C. Sm. in Buch) Dittrich	1940
Atractylis preauxiana	Sch. Bip.	1940	*Tanacetum ferulaceum*	(Webb) Sch. Bip.	1940
Carduus baeocephalus	Webb	1940	*Tanacetum oshanahanii*	"Marrero Rodr., Febles & Suárez"	1980
Carduus bourgeaui	Kazmi	1940			
Carduus clavulatus	Link	1940	*Tanacetum ptarmiciflorum*	(Webb) Sch. Bip.	1940
Carduus volutarioides	Reyes-Betancort	2000	*Tolpis calderae*	Bolle	1940
Carlina canariensis	Pit.	1940	*Tolpis crassiuscula*	Svent.	1940
Carlina falcata	Svent.	1940	*Tolpis glabrescens*	Kämmer	1940
Carlina texedae	Marrero Rodr.	1980	*Tolpis laciniata*	(Sch. Bip. ex Webb & Berthel.) Webb	1940
Carlina xeranthemoides	L. f.	1940			
Crepis canariensis	(Sch. Bip.) Babc.	1940	*Tolpis lagopoda*	C. Sm. in Buch	1940
Erigeron calderae	A. Hansen	1980	*Tolpis proustii*	Pit.	1940
Helichrysum alucense	"García-Casanova, S. Scholz & Hernández"	1990	*Tolpis webbii*	Sch. Bip. ex Webb & Berthel.	1940
Helichrysum gossypinum	Webb	1940	*Volutaria bollei*	(Sch. Bip. ex Bolle) A. Hansen & G. Kunkel	1940
Helichrysum monogynum	Burtt & Sunding	1970			
Hypochoeris oligocephala	(Svent. & Bramwell) Lack	1960	*Volutaria canariensis*	Wagenitz	1940
Kleinia neriifolia	Haw.	1940	*Lavatera acerifolia*	Cav.	1940
Lactuca palmensis	Bolle	1940	*Lavatera phoenicea*	Vent.	1940
Laphangium teydeum	Wildpret & Greuter	1940	*Adenocarpus foliolosus*	(Aiton) DC.	1940
Onopordon carduelium	Bolle	1940	*Adenocarpus ombriosus*	Ceballos & Ortuño	1940
Onopordon nogalesii	Svent.	1950	*Adenocarpus viscosus*	(Willd.) Webb & Berthel.	1940
Pericallis appendiculata	(L. f.) B. Nord.	1940	*Anagyris latifolia*	Brouss. ex Willd.	1940
Pericallis cruenta	(L`Hér.) Bolle	1940	*Chamaecytisus proliferus*	(L. f.) Link	1940
Pericallis echinata	(L. f.) B. Nord.	1940	*Cicer canariense*	A. Santos & G. P. Lewis	1960
Pericallis hadrosoma	(Svent.) B. Nord.	1940	*Dorycnium broussonetii*	(Choisy ex Ser. in DC.) Webb & Berthel.	1940
Pericallis hansenii	(G. Kunkel) Sunding	1980			
Pericallis lanata	(L`Hér.) B. Nord.	1940	*Dorycnium eriophthalmum*	Webb & Berthel.	1940
Pericallis multiflora	(L`Hér.) B. Nord.	1940	*Dorycnium spectabile*	(Choisy ex Ser. in DC.) Webb & Berthel.	1940
Pericallis murrayi	(Bornm.) B. Nord.	1940			
Pericallis papyracea	(DC.) B. Nord.	1940	*Genista benehoavensis*	(Bolle ex Svent.) del Arco	1940
Pericallis steetzii	(Bolle) B. Nord.	1940	*Lotus arinagensis*	Bramwell	1960
Pericallis tussilaginis	(L`Hér.) D. Don in Sweet	1940	*Lotus berthelotii*	Masf.	1940
Pericallis webbii	Sch. Bip. & Bolle	1940	*Lotus callis-viridis*	Bramwell & D. H. Davis	1950
Phagnalon umbelliforme	DC.	1940	*Lotus campylocladus*	Webb & Berthel.	1940
Pulicaria canariensis	Bolle	1940	*Lotus dumetorum*	Webb ex R. P. Murray	1940
Reichardia crystallina	(Sch. Bip.) Bramwell	1940	*Lotus emeroides*	R. P. Murray	1940
Reichardia famarae	Bramwell & G. Kunkel ex Gallego & Talavera	1940	*Lotus eremiticus*	A. Santos	1990
			Lotus genistoides	Webb	1970

Table S1. Continuation.

Native endemic species		Decade
Lotus hillebrandii	Christ	1940
Lotus holosericeus	Webb & Berthel.	1940
Lotus kunkelii	(Esteve) Bramwell & D. H. Davis	1940
Lotus lancerottensis	Webb & Berthel.	1940
Lotus maculatus	Breitf.	1980
Lotus mascaensis	Burchard	1940
Lotus pyranthus	P. Pérez	1980
Lotus sessilifolius	DC.	1940
Lotus spartioides	Webb & Berthel.	1940
Ononis angustissima	Lam.	1940
Ononis christii	Bolle	1940
Ononis hebecarpa	Webb & Berthel.	1940
Retama rhodorhizoides	Webb & Berthel.	1940
Teline canariensis	(L.) Webb & Berthel.	1940
Teline microphylla	(DC.) P. E. Gibbs & Dingwall	1940
Teline nervosa	(Esteve) A. Hansen & Sunding	1980
Teline osyrioides	(Svent.) P. E. Gibbs & Dingwall	1940
Teline pallida	(Poir.) G. Kunkel	1940
Teline rosmarinifolia	Webb & Berthel.	1940
Teline salsoloides	del Arco & Acebes	1980
Teline splendens	(Webb & Berthel.) del Arco	1940
Vicia chaetocalyx	Webb & Berthel.	1940
Vicia cirrhosa	C. Sm. ex Webb & Berthel.	1940
Vicia filicaulis	Webb & Berthel.	1960
Vicia nataliae	U. Reifenberger & Reifenberger	1990
Vicia scandens	R. P. Murray	1940
Justicia hyssopifolia	L.	1940
Camptoloma canariense	(Webb & Berthel.) Hilliard	1940
Campylanthus salsoloides	(L. f.) Roth	1940
Isoplexis canariensis	(L.) J. W. Loudon	1940
Isoplexis chalcantha	Svent. & O'Shan.	1940
Isoplexis isabelliana	(Webb & Berthel.) Masf.	1940
Kickxia pendula	(G. Kunkel) G. Kunkel	1960
Kickxia scoparia	(Brouss. ex Spreng.) G. Kunkel & Sunding	1940
Scrophularia calliantha	Webb & Berthel.	1940
Scrophularia glabrata	Aiton	1940
Scrophularia smithii	Hornem.	1940
Orobanche berthelotii	Webb & Berthel.	1990
Orobanche gratiosa	(Webb & Berthel.) Linding.	1940
Globularia ascanii	Bramwell & G. Kunkel	1980
Globularia sarcophylla	Svent.	1950
Plantago asphodeloides	Svent.	1940
Plantago famarae	Svent.	1940
Plantago webbii	Barnéoud	1940
Bosea yervamora	L.	1940
Cerastium sventenii	Jalas	1940
Herniaria canariensis	Chaudhri	1960
Herniaria hartungii	Parl.	1940
Minuartia platyphylla	(Gay ex Christ) McNeill	1940
Minuartia webbii	McNeill & Bramwell	1940
Paronychia canariensis	(L. f.) Juss.	1940
Polycarpaea aristata	(Aiton) DC.	1940
Polycarpaea carnosa	C. Sm. ex Buch	1940
Polycarpaea divaricata	(Aiton) Poir.	1940
Polycarpaea filifolia	Webb ex Christ	1940
Polycarpaea latifolia	Willd.	1940
Polycarpaea robusta	(Pit.) G. Kunkel	1990
Polycarpaea smithii	Link	1940
Polycarpaea tenuis	Webb ex Christ	1940

Native endemic species		Decade
Silene berthelotiana	Webb	1940
Silene bourgeaui	Webb ex Christ	1940
Silene canariensis	Willd.	1990
Silene lagunensis	C. Sm. ex Christ	1940
Silene nocteolens	Webb & Berthel.	1940
Silene sabinosae	Pit.	1940
Silene tamaranae	Bramwell	1940
Chenopodium coronopus	Moq. in DC.	1940
Patellifolia webbiana	"(Moq.) A. J. Scott, Ford-Lloyd & J. T. Williams"	1940
Salsola divaricata	Masson ex Link in Buch	1940
Aeonium appendiculatum	A. Bañares	1940
Aeonium arboreum	(L.) Webb & Berthel.	1940
Aeonium balsamiferum	Webb & Berthel.	1940
Aeonium canariense	(L.) Webb & Berthel.	1940
Aeonium castello-paivae	Bolle	1940
Aeonium ciliatum	(Willd.) Webb & Berthel.	1940
Aeonium cuneatum	Webb & Berthel.	1940
Aeonium davidbramwellii	H. Y. Liu	1940
Aeonium decorum	Webb ex Bolle	1940
Aeonium gomerense	(Praeger) Praeger	1940
Aeonium goochiae	(Webb & Berthel.) Webb & Berthel.	1940
Aeonium haworthii	(Salm-Dyck ex Webb & Berthel.) Webb & Berthel.	1940
Aeonium hierrense	(R. P. Murray) Pit. & Proust	1940
Aeonium lancerottense	(Praeger) Praeger	1940
Aeonium lindleyi	Webb & Berthel.	1940
Aeonium nobile	(Praeger) Praeger	1940
Aeonium percarneum	(R. P. Murray) Pit.	1940
Aeonium pseudourbicum	A. Bañares	1940
Aeonium saundersii	Bolle	1940
Aeonium sedifolium	(Webb ex Bolle) Pit. & Proust	1940
Aeonium simsii	(Sweet) Stearn	1940
Aeonium smithii	(Sims) Webb & Berthel.	1940
Aeonium spathulatum	(Hornem.) Praeger	1940
Aeonium tabulaeforme	(Haw.) Webb & Berthel.	1940
Aeonium undulatum	Webb & Berthel.	1940
Aeonium urbicum	(C. Sm. ex Buch) Webb & Berthel.	1940
Aeonium valverdense	(Praeger) Praeger	1940
Aeonium volkerii	Hernández & A. Bañares	1940
Aichryson bethencourtianum	Bolle	1940
Aichryson bituminosum	A. Bañares	1940
Aichryson bollei	Webb ex Bolle	1940
Aichryson brevipetalum	Praeger	1940
Aichryson laxum	(Haw.) Bramwell	1940
Aichryson pachycaulon	Bolle	1940
Aichryson palmense	Webb ex Bolle	1940
Aichryson parlatorei	Bolle	1940
Aichryson porphyrogennetos	Bolle	1940
Aichryson punctatum	(C. Sm. ex Buch) Webb & Berthel.	1940
Aichryson tortuosum	(Aiton) Webb & Berthel.	1940
Monanthes anagensis	Praeger	1940
Monanthes brachycaulos	(Webb in Webb & Berthel.) Lowe	1940
Monanthes icterica	(Webb ex Bolle) Christ	1940
Monanthes laxiflora	(DC.) Bolle	1940
Monanthes minima	(Bolle) Christ	1940
Monanthes muralis	(Webb ex Bolle) Hook. f.	1940
Monanthes pallens	(Webb ex Christ) Christ	1940
Monanthes polyphylla	Haw.	1940

Table S1. Continuation.

Native endemic species		Decade
Monanthes wildpretii	A. Bañares & S. Scholz	1980
Bencomia brachystachya	Svent. ex Nordborg	1940
Bencomia exstipulata	Svent.	1950
Bencomia sphaerocarpa	Svent.	1940
Marcetella moquiniana	(Webb & Berthel.) Svent.	1940
Rubus palmensis	A. Hansen	1970
Ruta microcarpa	Svent.	1940
Ruta oreojasme	Webb	1940
Ruta pinnata	L. f.	1940
Bystropogon canariensis	(L.) L`Hér.	1940
Bystropogon odoratissimus	Bolle	1940
Bystropogon origanifolius	L`Hér.	1940
Bystropogon plumosus	(L. f.) L`Hér.	1940
Bystropogon wildpretii	La Serna	1960
Lavandula bramwellii	Upson & S. Andrews	1980
Lavandula buchii	Webb	1940
Lavandula canariensis	Mill.	1940
Lavandula minutolii	Bolle	1940
Micromeria benthamii	Webb & Berthel.	1940
Micromeria glomerata	P. Pérez	1970
Micromeria helianthemifolia	Webb & Berthel.	1940
Micromeria herpyllomorpha	Webb & Berthel.	1940
Micromeria hyssopifolia	Webb & Berthel.	1940
Micromeria lachnophylla	Webb & Berthel.	1940
Micromeria lanata	(C. Sm. ex Link) Benth.	1940
Micromeria lasiophylla	Webb & Berthel.	1940
Micromeria lepida	Webb & Berthel.	1940
Micromeria leucantha	Svent. ex P. Pérez	1980
Micromeria pineolens	Svent.	1940
Micromeria rivas-martinezii	Wildpret	1980
Micromeria teneriffae	(Poir.) Benth.	1940
Micromeria tenuis	(Link) Webb & Berthel.	1940
Nepeta teydea	Webb & Berthel.	1940
Salvia broussonetii	Benth.	1940
Salvia canariensis	L.	1940
Salvia herbanica	A. Santos & M. Fernández	1980
Sideritis amagroi	Marrero Rodr. & Navarro	1990
Sideritis barbellata	Mend.-Heuer	1940
Sideritis brevicaulis	Mend.-Heuer	1940
Sideritis canariensis	L.	1940
Sideritis cretica	L.	1940
Sideritis cystosiphon	Svent.	1960
Sideritis dasygnaphala	(Webb & Berthel.) Clos emend. Svent.	1940
Sideritis dendro-chahorra	Bolle	1940
Sideritis discolor	Bolle	1940
Sideritis eriocephala	Marrero Rodr. ex Negrín & P. Pérez	1940
Sideritis ferrensis	P. Pérez & Negrín	1950
Sideritis gomerae	Bolle	1940
Sideritis infernalis	Bolle	1940
Sideritis kuegleriana	Bornm.	1940
Sideritis lotsyi	(Pit.) Bornm.	1940
Sideritis macrostachys	Poir.	1940
Sideritis marmorea	Bolle	1940
Sideritis nervosa	(Christ) Linding.	1940
Sideritis nutans	Svent.	1950
Sideritis oroteneriffae	Negrín & P. Pérez	1940
Sideritis pumila	(Christ) Mend.-Heuer	1940
Sideritis soluta	Clos	1940
Sideritis sventenii	(G. Kunkel) Mend.-Heuer	1970
Thymus origanoides	Webb & Berthel.	1940
Brassica bourgeaui	(Webb ex Christ) Kuntze	1940
Crambe arborea	Webb ex Christ	1940

Native endemic species		Decade
Crambe gomerae	Webb ex Christ	1940
Crambe laevigata	DC. ex Christ	1940
Crambe microcarpa	A. Santos	1980
Crambe pritzelii	Bolle	1940
Crambe santosii	Bramwell	1940
Crambe scaberrima	Webb ex Bramwell	1940
Crambe scoparia	Svent.	1950
Crambe strigosa	L`Hér.	1940
Crambe sventenii	Pett. ex Bramwell & Sunding	1950
Crambe tamadabensis	A. Prina & Á. Marrero	1980
Crambe wildpretii	A. Prina & Bramwell	1960
Descurainia artemisioides	Svent.	1940
Descurainia bourgeauana	(E. Fourn.) O. E. Schulz	1940
Descurainia gilva	Svent.	1940
Descurainia gonzalesii	Svent.	1940
Descurainia lemsii	Bramwell	1940
Descurainia millefolia	(Jacq.) Webb & Berthel.	1940
Descurainia preauxiana	(Webb) O. E. Schulz	1940
Erucastrum canariense	Webb & Berthel.	1940
Erysimum albescens	(Webb & Berthel.) Bramwell	1940
Erysimum scoparium	(Brouss. ex Willd.) Wettst.	1940
Matthiola bolleana	Webb ex Christ	1940
Reseda crystallina	Webb & Berthel.	1940
Reseda scoparia	Brouss. ex Willd.	1940
Ammodaucus nanocarpus	(E. Beltrán) P. Pérez & A. Velasco	1940
Bupleurum handiense	(Bolle) G. Kunkel	1940
Cryptotaenia elegans	Webb ex Bolle	1940
Ferula lancerottensis	Parl.	1940
Ferula latipinna	A. Santos	1980
Ferula linkii	Webb	1940
Pimpinella anagodendron	Bolle	1940
Pimpinella cumbrae	Link	1940
Pimpinella dendrotragium	Webb	1940
Pimpinella junoniae	Ceballos & Ortuño	1940
Pimpinella rupicola	Svent.	1940
Seseli webbii	Coss.	1940
Echium acanthocarpum	Svent.	1950
Echium aculeatum	Poir.	1940
Echium auberianum	Webb & Berthel.	1940
Echium bethencourtii	A. Santos	1980
Echium bonnetii	Coincy	1940
Echium brevirame	Sprague & Hutch.	1940
Echium callithyrsum	Webb ex Bolle	1940
Echium decaisnei	Webb	1940
Echium gentianoides	Webb ex Coincy	1940
Echium giganteum	L. f.	1940
Echium handiense	Svent.	1940
Echium hierrense	Webb ex Bolle	1940
Echium lancerottense	Lems & Holzapfel	1940
Echium leucophaeum	Webb ex Sprague & Hutch.	1940
Echium onosmifolium	Webb	1940
Echium pininana	Webb & Berthel.	1940
Echium simplex	DC.	1940
Echium strictum	L. f.	1940
Echium sventenii	Bramwell	1960
Echium triste	Svent.	1940
Echium virescens	DC.	1940
Echium webbii	Coincy	1940
Echium wildpretii	Pearson ex Hook. f.	1940
Euphorbia aphylla	Brouss. ex Willd.	1940
Euphorbia atropurpurea	(Brouss.) Webb & Berthel.	1940
Euphorbia berthelotii	Bolle	1940
Euphorbia bourgeauana	Gay ex Boiss. in DC.	1940

Table S1. Continuation.

Native endemic species		Decade
Euphorbia bravoana	Svent.	1940
Euphorbia canariensis	L.	1940
Euphorbia handiensis	Burchard	1940
Euphorbia lamarckii	Sweet	1940
Euphorbia lambii	Svent.	1950
Arbutus canariensis	Veill.	1940
Erica platycodon	(Webb & Berthel.) Rivas-Mart. & al.	1940
Fumaria coccinea	Lowe ex Pugsley	1980
Ceropegia dichotoma	Haw.	1940
Ceropegia fusca	Bolle	1940
Phyllis viscosa	Webb ex Christ	1940
Normania nava	(Webb & Berthel.) Franc.-Ort. & R. N. Lester	1940
Solanum lidii	Sunding	1960
Solanum vespertilio	Aiton	1940
Convolvulus canariensis	L.	1940
Convolvulus caput-medusae	Lowe	1940
Convolvulus floridus	L. f.	1940
Convolvulus fruticulosus	Desr.	1940
Convolvulus glandulosus	(Webb) Hallier f.	1940
Convolvulus lopezsocasi	Svent.	1940
Convolvulus perraudieri	Coss.	1940
Convolvulus scoparius	L. f.	1940
Convolvulus subauriculatus	(Burchard) Linding.	1940
Convolvulus volubilis	Link in Buch	1940
Bryonia verrucosa	Dryand.	1940
Campanula occidentalis	Y. Nyman	1940
Canarina canariensis	(L.) Vatke	1940
Forsskaolea angustifolia	Retz.	1940
Gesnouinia arborea	(L. f.) Gaudich.	1940
Parietaria filamentosa	Webb & Berthel.	1940
Urtica stachyoides	Webb & Berthel.	1940
Pterocephalus dumetorus	(Brouss. ex Willd.) Coult.	1940
Pterocephalus lasiospermus	Link ex Buch	1940
Pterocephalus porphyranthus	Svent.	1940
Pterocephalus virens	Webb & Berthel.	1940
Sambucus palmensis	Link	1940
Viburnum rigidum	Vent.	1940
Cistus asper	Demoly & R. Mesa	2000
Cistus chinamadensis	A. Bañares & P. Romero	1980
Cistus horrens	Demoly	1960
Cistus ocreatus	C. Sm. in L. von Buch	1940
Cistus osbeckiifolius	Webb & Christ	1940
Cistus palmensis	Bañares & Demoly	2000
Cistus symphytifolius	Lam.	1940
Helianthemum bramwelliorum	Marrero Rodr.	1990
Helianthemum broussonetii	Dunal ex DC.	1940
Helianthemum bystropogophyllum	Svent.	1950
Helianthemum gonzalezferreri	Marrero Rodr.	1990
Helianthemum inaguae	"Marrero Rodr., González-Martín & González-Artiles"	1980
Helianthemum juliae	Wildpret	1980
Helianthemum teneriffae	Coss.	1940
Helianthemum tholiforme	"Bramwell, J. Ortega & B. Navarro"	1980
Helianthemum thymiphyllum	Svent.	1950
Viola anagae	Gilli	1980
Viola cheiranthifolia	Humb. & Bonpl.	1940
Viola palmensis	Webb & Berthel.	1940
Rumex lunaria	L.	1940
Geranium reuteri	Aedo & Muñoz Garm.	1940
Hypericum coadunatum	C. Sm. ex Link	1940
Hypericum reflexum	L. f.	1940

Native endemic species		Decade
Olea cerasiformis	Rivas-Mart. & del Arco	1940
Limonium arborescens	(Brouss.) Kuntze	1940
Limonium benmageci	Marrero Rodr. in Marrero Rodr. & Almeida	2000
Limonium bourgeaui	(Webb ex Boiss.) Kuntze	1940
Limonium brassicifolium	(Webb & Berthel.) Kuntze	1940
Limonium dendroides	Svent.	1950
Limonium fruticans	(Webb) Kuntze	1940
Limonium imbricatum	(Webb ex Girard) C. F. Hubb.	1940
Limonium macrophyllum	(Brouss.) Kuntze	1940
Limonium perezii	(Stapf) C. F. Hubb.	1940
Limonium preauxii	(Webb & Berthel.) Kuntze	1940
Limonium puberulum	(Webb) Kuntze	1940
Limonium redivivum	(Svent.) G. Kunkel & Sunding	1950
Limonium relicticum	R. Mesa & A. Santos	2000
Limonium spectabile	(Svent.) G. Kunkel & Sunding	1940
Limonium sventenii	A. Santos & M. Fernández	1970
Limonium vigaroense	Marrero Rodr. & Almeida	2000
Maytenus canariensis	(Loes.) G. Kunkel & Sunding	1940
Myrica rivas-martinezii	A. Santos	1980
Rhamnus crenulata	Aiton	1940
Rhamnus integrifolia	DC.	1940
Sideroxylon canariensis	"T. Leyens, W. Lobin & A. Santos "	1940
Arrhenatherum calderae	A. Hansen	1940
Avena canariensis	"R. Baum, Rajhathy & D. R. Sampson "	1940
Brachypodium arbuscula	Knoche	1940
Dactylis metlesicsii	Schönfelder & Ludwig	1980
Festuca agustinii	Linding.	1940
Lolium edwardii	"H. Scholz, Stierstorfer & v.Gaisberg "	1940
Melica teneriffae	Hack. ex Christ	1940
Oropetium capense	Stapf	2000
Poa pitardiana	H. Scholz	1940
Trisetaria lapalmae	H. Scholz	1980
Asparagus arborescens	Willd.	1940
Asparagus fallax	Svent.	1940
Asparagus plocamoides	Webb ex Svent.	1940
Semele gayae	(Webb) Svent. & G. Kunkel	1940
Pancratium canariense	Ker-Gawl.	1940
Dracaena tamaranae	"Marrero Rodr., Almeida-Pérez & González-Martín"	1980
Scilla dasyantha	Webb & Berthel.	1940
Scilla haemorrhoidalis	Webb & Berthel.	1940
Androcymbium hierrense	A. Santos	1980
Androcymbium psammophilum	Svent.	1940
Dracunculus canariensis	Kunth	1940
Carex canariensis	Kük.	1940
Carex perraudieriana	Gay ex Bornm.	1940
Luzula canariensis	Poir.	1940
Habenaria tridactylites	Lindl.	1940
Himantoglossum metlesicsianum	(W. P. Teschner) P. Delforge	1970
Serapias mascaensis	"H. Kretzschmar, G. Kretzschmar & Kreutz"	1990
Phoenix canariensis	Chabaud	1940
Pinus canariensis	C. Sm. ex DC. in Buch	1940
Asplenium terorense	G. Kunkel	1960
Dryopteris oligodonta	(Desv.) Pic.-Serm.	1940

Figure 2. Species and decade scores in the space defined by axes I and II of DCA based on the presence of the invasive thermophile species following the Arechavaleta Hernández *et. al* (2010) check list. Eigenvalues of axes I and II were 1.330 and 0.511, respectively, and the cumulative percentage of variance explained by both axes was 65.2 %. The names of the species use the first three letters of the genus and the first three letters of the specific epithet (Table 1 for species full names).

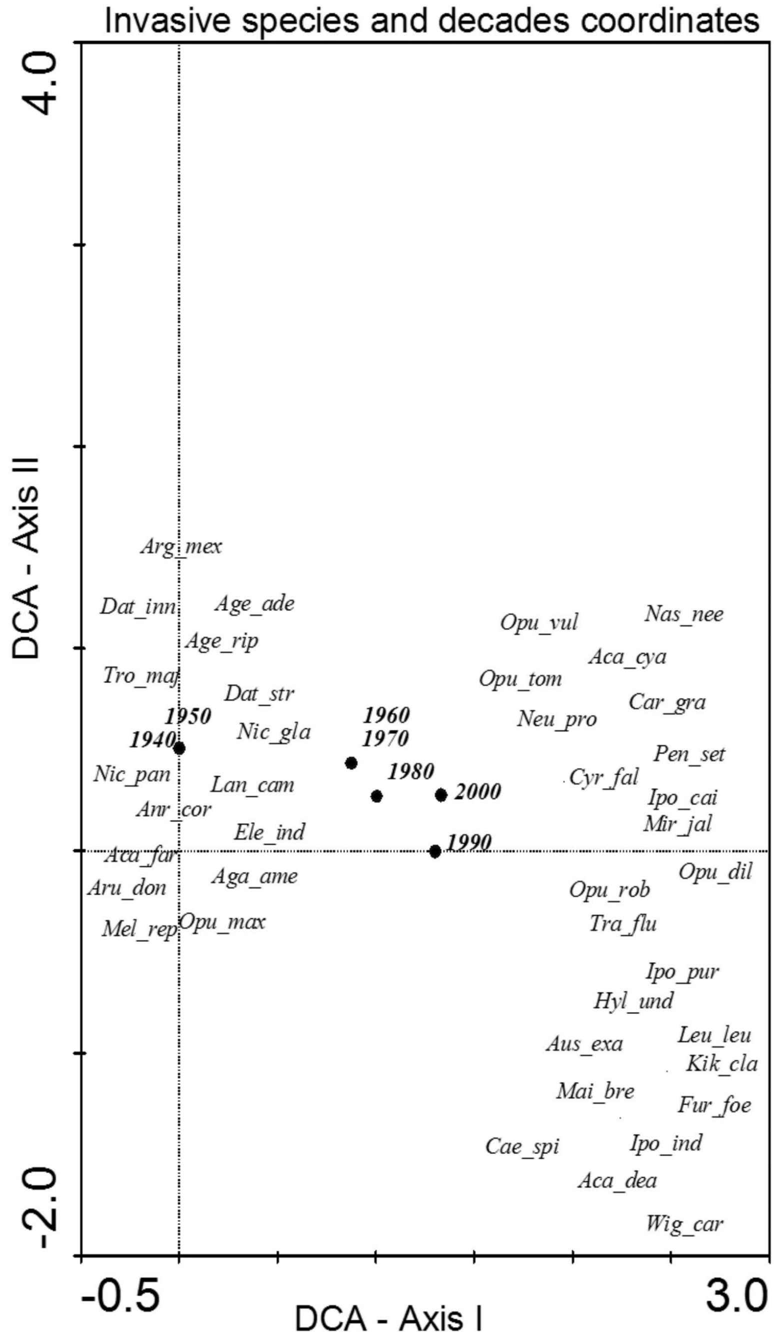


Table 3. Socioeconomic and climatic information (GDP: Gross domestic product in millions €; POP: Resident population; TOU: Millions of tourists; TEM: mean temperature anomalies; mTEM: minimum mean temperature anomalies).

Decade	GDP	POP	TOU	TEM	mTEM
1940	44	813290	15	-0.207	-0.473
1950	1.801	974989	73	-0.203	-0.495
1960	5.264	1137599	792	0.151	0.010
1970	10.191	1388243	2228	-0.155	-0.292
1980	19142	1621710	5459	0.044	0.090
1990	32059	1767867	9975	0.077	0.179
2000	42097	2219846	8611	0.344	0.463

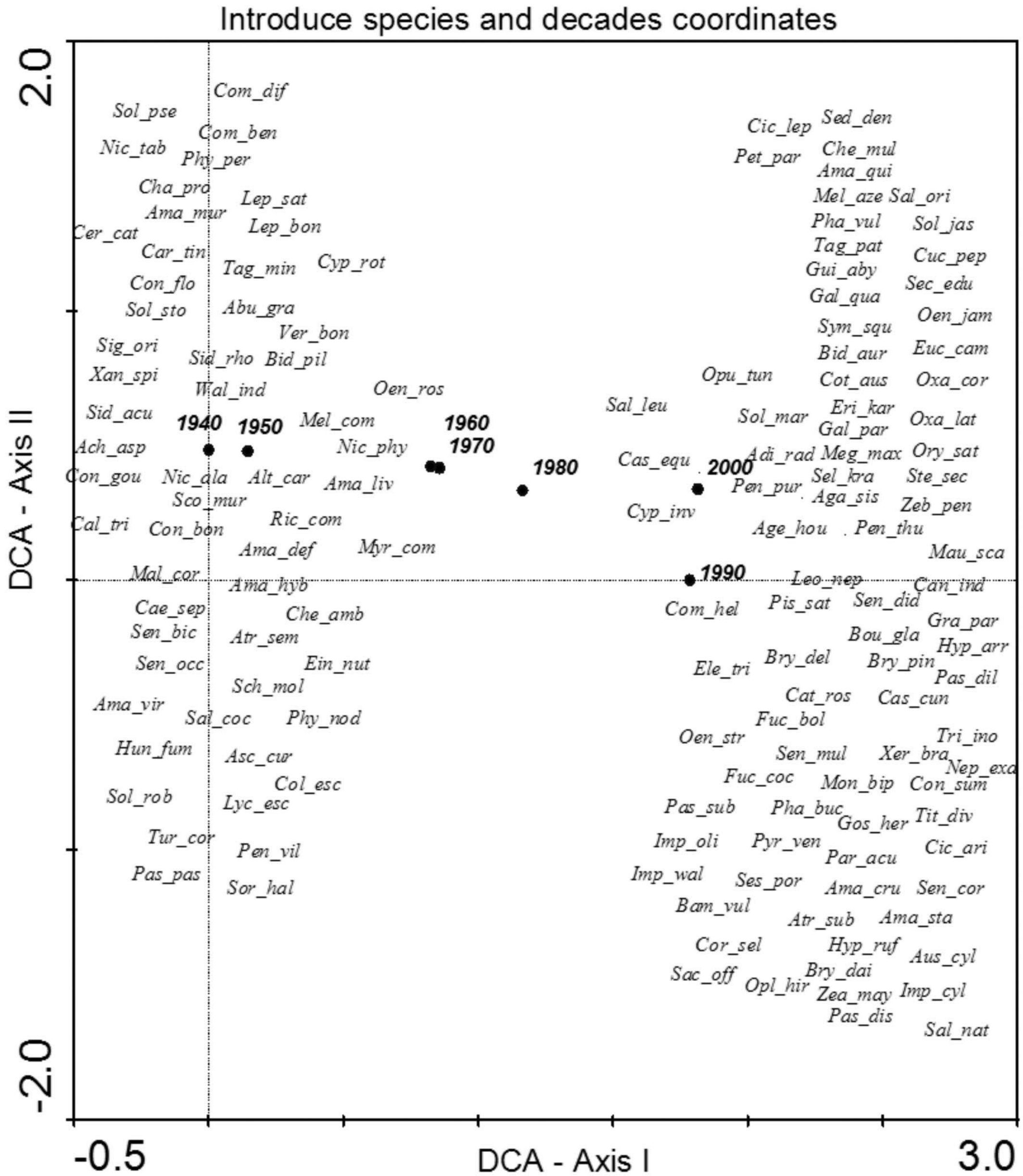


Figure 3. Species and decade scores in the space defined by axes I and II of DCA based on the presence of the introduced thermophile species following the Arechavaleta Hernández *et. al* (2010) check list. Eigenvalues of axes I and II were 1.813 and 0.484, respectively, and the cumulative percentage of variance explained by both axes was 70.8 %. The names of the species use the first three letters of the genus and the first three letters of the specific epithet (Table 2 for species full names).

Table 4. Pearson correlation coefficients for decades coordinates on axes I and II of DCA and socioeconomic and temperature anomaly variables.

	DCA - Axis I			DCA - Axis II		
Variables	*Invasive*	*Introduce*	*Native*	*Invasive*	*Introduce*	*Native*
GDB	0.843	0.943**	0.970**	-0.793	-0.691	0.521
POP	0.887	0.948**	0.968**	-0.725	-0.604	0.529
TUR	0.839	0.942*	0.967**	-0.929	-0.856	0.267
TEM	0.809	0,819	0.779	-0.533	-0.413	0.589
mTEM	0.911	0.936**	0.918	-0.720	-0.598	0.478

After multiple test Holm´s procedure (*) p <0.01; (**) p < 0.05; n = 7.

Figure 4. Decade scores in the space defined by axes I and II of DCA based on the presence of the native species following the Arechavaleta Hernández *et. al* (2010) check list. Eigenvalues of axes I and II were 0.672 and 0.195, respectively, and the cumulative percentage of variance explained by both axes was 69.8 %.

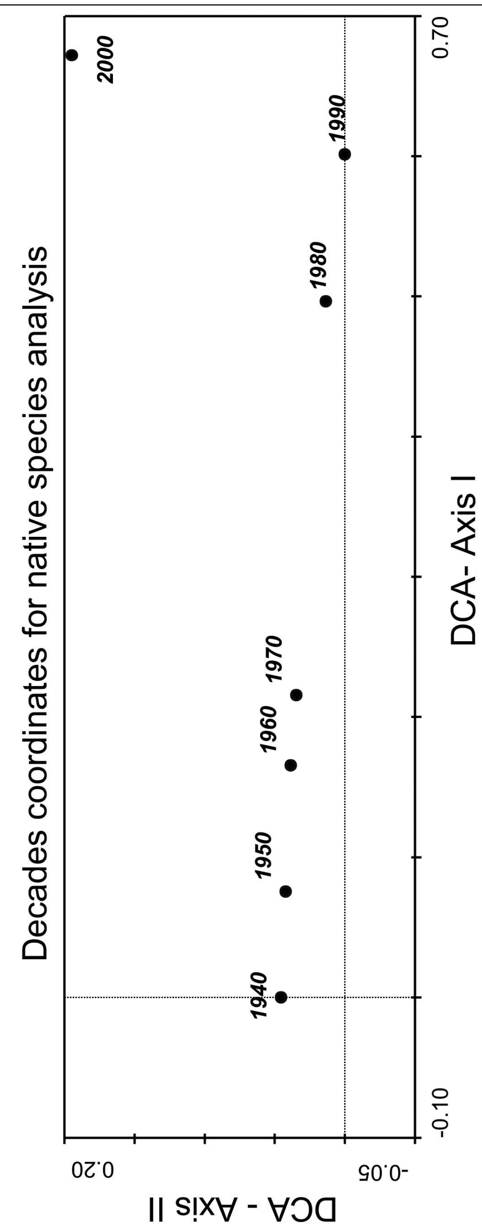


Table 5. Pearson correlation coefficients for species richness over the decades and socioeconomic and temperature anomalies variables.

Variables	*Invasive*	*Introduce*	*Native*
GDB	0.913	0.979*	0.946**
POP	0.931	0.942**	0.966*
TOU	0.906	0.970*	0.945**
TEM	0.832	0.802	0.782
mTEM	0.938**	0.913	0.918

After multiple test Holm´s procedure (*) $p < 0.01$; (**) $p < 0.05$; n = 7.

are also correlated with these variables and with mTEM; while invasive species revealed no correlation with any of the parameters used in the analysis. The DCA-Axis II did not reveal any correlation among these variables with the decade coordinates (Table 4).

The direct gradient analysis (CCA) also showed similar patterns to the DCA. In the case of invasive species, the Montecarlo Test for the decade scores of CCA-Axis I with respect to the 4 explanatory variables (499 iterations) indicated that the only variable explaining species composition all along the axis is TOU ($F = 6.25$; $p < 0.001$), with the same result for the introduced ones ($F = 9.110$; $p < 0.01$), while for native, GDP was the only variable ($F = 9.01$, $p < 0.01$).

The correlation of species richness with the variables revealed a similar pattern for native and introduced species, where GDP, POP and TOU were significantly correlated with the increase in species richness, while for invasive, the correlated variable explaining the variability of species richness of this group was mTEM (Table 5).

Discussion

Species invasions are governed by factors such as environmental conditions and species traits as well as human activities (Pyšek *et al*. 2010). It is well known that socioeconomic variables are driving forces of invasion across national and international boundaries (population, international trade, globalization economy, transport…); while aspects related to global warming and climate change appear to have less effect in some studies (Le Maitre *et al*. 2004) and as our results in this study demonstrate. The degree of development is directly related to the number of invasive species and the impact can be immediately evident or lag for a period over 100 years (Weber & Li 2008).

In our study, we have found a faster rate of increase in the number of invasive and introduced species than in the number of native species during these decades (Figure 1). Based on absolute numbers, introduced species is the group that has been increasing the fastest over the last seven decades. It is also true that we have centered the study on thermophile invasive and introduced species, as they have been considered more adaptable and responsive to global warming (Sobrino *et al*. 2001). Global warming is considered to affect ecophysiological processes of plant systems resulting in advances of thermophilic species and expansion of their ranges (Hilbert *et al*. 2001, Sobrino *et al*. 2001). Increases in CO_2 and in temperature are determining factors related to the prevalence of invaders (Dukes & Mooney 1999).

In spite of the importance of global warming in favoring species to reach, up till now otherwise inhabitable areas (i.e. high altitudinal zones; Pauchard *et al*. 2009), we have found that socioeconomic aspects of development (GDP, POP and TOU) are important elements that better explain the increase in richness and changes in species composition. However, mTEM appears in these correlations as significant in the case of invasive species richness and in the case of DCA introduce species composition. The results are in some way similar to other studies, where economic variables similar to GDP (i.e. per capita real state) have been found as the most important variables to explain the distribution of non-native species (Taylor & Irwin 2004), as well as other indicators, such as the human development index (Weber & Li 2008) or population movements (Margolis *et al*. 2005). Population and tourism, in our case, have been revealed as the most consistent variables to explain species composition and species richness. In fact, these are the only variables that explain changes in invasive species composition and richness (Table 4) and are significant in other analyses, as demonstrated in other studies (Pyšek *et al*. 2010, Lockwood *et al*. 2005).

In our study, the increase in mTEM has only been significant in the case of invasive richness and introduced species composition. In other studies related to altitudinal gradients, minimum temperatures appear as a good predictor to displace the tree or other species line at higher altitudes (Dukes *et al*. 2009), including invasive ones, which have been revealed as another threat to well-protected altitudinal areas (Sheppard *et al*. 2014; Pauchard *et al*. 2009).

The number of tourist has not often been considered in studies about determinants that drive introduced species. In our case, it is very closely related to the number of introduced species, although it was also significant for the other groups of species richness as well as for explaining species composition. Tourism is the principal economic activity of the archipelago, with over 12 million visitors in 2012 (with an average stay of 10 days). We should consider the impact of tourism not just as a number, but also in terms of the numerous activities associated with tourism (excursions, spectacles, transport).

We expected that temperature anomalies (minimum) would play a more significant role in the changes in species composition and richness over the decades. In fact, we selected the thermophile species, expecting to favor the appearance of significant relationships. However, these relationships have been found to be very low, even when analyzing the data individually with species richness. In spite of these results, we still consider that temperature anomalies, as long as they follow IPCC predictions, will become an important driver of species invasion. Climatic changes predicted by the IPCC in the Mediterranean area are likely to determine significant changes in species forest composition. In fact, the moderate scenarios of the IPCC predict a severe decrease in precipitations and a rise of 3–4 °C in average temperatures (de Castro *et al*. 2004), with a similar scenario for Canary Islands based on the newest and most sensitive IPCC estimations (IPCC 2013). So far, changes detected over the past 70 years have not reached 2 °C. This could be the reason why this effect is not detectable yet, and also because of the great socioeconomic changes that affected the Canary Islands during these decades (tourism boom in the 60s, the arrival of democracy in 1974, joining the European Community 1984, etc.).

One of the results common to both native and introduced species is that they are affected by the same socioeconomic factors (although invasives were only significantly related to population), following the pattern that is known as "what it is good for native is also good for introduced species" (Stohlgren *et al*. 1999, Foster *et al*. 2002). In this case, despite the appearance of new of native or introduced species, we cannot relate this appearance to a "biological invasion crisis" but to a deeper economic development of the Canary Islands' society that invests more in research and discovery of species. In fact, in the last five decades in Canary Islands has been described an average of three new species of terrestrial flora each year (Martín *et al*. 2005). It is also true that this economic development favors propagule dispersion at a faster rate than the appearance of native species, as found in our data, and this should be an important concern for environmental managers (Figure 1). As globalization is a force that favors propagule pressure (Lockwood *et al*. 2005), its association with the increase in the number of introduced species comes as no surprise. Something similar happens with the observed relationship between the invaders and mTEM; the less important the temperature is as a limiting factor, the greater the chances of survival, allowing better growth of alien species in the range introduced. This has been identified as one of the expected effects of climate change on biodiversity (Walther *et al*. 2009).

Climate change, including increased temperatures, decreased rainfall, and variation in daily/seasonal temperature ranges may facilitate the geographical extension of many invasive species, threatening native biodiversity (Caujape-Castells *et al*. 2010). Continuous monitoring and control of areas where non-native species are concentrated, including botanical gardens, personal gardens, landscaped public and government buildings, and commercial garden centers, among others, is recommended to prevent accidental escape and expansion of thermophile species favored by climate change in the near future, as has been recently suggested by McDougall *et al*. (2011). For Tenerife Island, golf courses are one of the main entrance of non-native species (Siverio 2012), becoming one of the main areas to control (not just the target species used for the field, also the involuntary introduce in the seeds and soil. The number of exotic species blacklisted should be expanded to include species that have an increased likelihood of becoming feral due to local warming. As it is revealed in this study, together with economic growth, the entrance of introduce species are expected to increase.

We cannot forget the importance of laws and regulation in order to control the movement an entrance of invasive and introduce species. A new Royal Decree Law (Real Decreto Ley 630/2013, 2013) has been enacted and approves to regulate the invasive and introduce species and stablishing strong limitations to the use.

Since 2007, the economic crisis has changed many socioeconomic variables in this study (study finished in 2010). Thus, in future studies, we will have a good opportunity to reveal the importance of the temperature anomalies (minimum and average) in species richness and composition. Clearly, multidisciplinary efforts will be necessary between ecologists and economists to reveal the external cost of the increasing presence of non-native species caused by economic growth. This will be valuable information before declaring and then facing battle against any future "biological invasion crises".

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