Invasive Plants in the Coastal Vegetal Communities in Valencia (Spain)

Francisco FERRER MERINO, Pilar M. DONAT

Universidad Politécnica de Valencia, EPS Gandia,Dto. Ecosistemas Agroforestales. Carretera Nazaret-Oliva s/n, 46730, Gandia, Spain; mmpdonat@eaf.upv.es

Abstract

A botanical survey has been conducted to determine the influence of invasive species on the main indigenous communities in the Spanish Mediterranean coast and evaluate the current status of these communities in the eastern coast of Spain. The work was done in about 35 km of coastline located in Valencia (Spain). A total of 361 species cataloged are present in the study area, belonging to 79 different families. 49 of them have been inventoried invasive species which currently affect 38 plant communities. For this cause, we have developed a map of location finding out the area occupied by the same at every point and key to indigenous communities it affects. The plant communities characteristic of semi-mobile dunes Centaureo maritimae-Echietum sabulicolae and Medicagini marinae-Ammophiletum australis have turned out to have a greater degree of invasion. Carpobrotus edulis, Agave americana, Arundo donax, Oxalis pes-caprae and Cortaderia selloiana are invasive species that cause further encroachment, both in area as a number of vegetation communities they affect.

Keywords: coastal vegetation, dunes, habitat directive, invasive plants, Valencian vegetation

Introduction

The colonisation of invasive alien plants in the coastal ecosystems is one of the causes of the native flora population decline (Vilá, 2008). In the Mediterranean coast of Valencia has long been found species with an invasive behaviour, and many studies have been carried out on some of them, with control actions over their population as well (Silveira et al., 2010). But the existence of many other invasive species has been detected, which could be significantly affecting the coastal vegetation (Chamarro et al., 2010).

The aim of this study is to evaluate the degree of invasion of the natural coastal ecosystems and the impact they are supporting on them, to take appropriate conservation measures. The main hypothesis is that the qualitative and quantitative presence of invasive plants is bigger than the detected until now and could have negative influences to all coastal plant communities.

The study area is a Mediterranean coastal strip located in Valencia (SE Spain). This area is located between the mouths of Jucar river, on the north (UTM European Datum: Time 30S 738548.437493) and Racons river, on the south (757286.4308407). Its length is 33 Km and has an average width of 47.6 m. This is a mostly a coastline of sandy sediment in which the width dunes were only interrupted by mouths of rivers and channels (Costa, 1999).

Natural dune areas are now between large urban centres. Inland, behind the dunes and farther from the sea, there are some wetlands, valuable remnants of the vast marsh that existed north and south of the territory.

The study area is protected by European, national and local legislation.

In the study area there are several SCIs (Sites of Community Importance included in Natura 2000 network). One SCI includes the coastal dunes of la Safor, other two the mouths of rivers Jucar and Racons, and the forth an adjacent wetland (“Marsh of La Safor”).

- The local legislation level is the “Catalogue of Wetlands”, in which are included the mouths of these rivers and several wetlands of the area or close to it.

- The national legislation level is the Spanish Coastal Law, to protect the sea shore, dunes and adjacent wetlands.

Regarding the bioclimatic features, the thermotype presented in this area is Superior Thermomediterranean with an Inferior Subhumid ombrotype (Rivas-Martínez, 2008).

Material and methods

At first, in the study the flora of the coastal habitats and the plant communities have been catalogued and inventoried, identifying associations that are ascribed to habitats of the Habitats Directive of the European Union. The invasive species also have been incorporated into the catalogue. Secondly, it has been realised a detail study of 28 invasive species. All located individuals have been mapped and their area has been estimated. The invasive species of the same genus which are demonstrating a similar behaviour regarding to the invasion of communities of vegetation have been classified as genus.
The field work was carried out during two years, visiting the area regularly, covering entirely the coast in different seasons of the year. The location of different taxa was carried out, using GPS, orthophotos and maps of the area, and with these data a geodatabase using Arc GIS programs for Windows V.3.2 has been done.

The specific definition of the study area was carried out following the location of vascular plants from the shore line to the first human constructions, as promenades and buildings, if they exist in front of the beach. In the absence of these constructions, the inventory reached few meters behind the dunes. This covers a study area between 10 and 150 m wide.

The development of floristic list is based on the in situ identification of the taxa and, exceptionally, their collection for subsequent determination. The voucher specimens are preserved in the GAN Herbarium of the Polytechnic University of Valencia (UPV).

For the identification and nomenclature of taxa the following criteria have been followed: Mateo and Crespo (2009), “Flora Ibérica” (Castroviejo et al., 1986-2010), “Flora Europaea” (Tutin et al., 1964-1980, 2002) and the “Flora Ornamental Española” (Spanish Ornamental Plants) for invasive species (López Lillo et al., 2007).

To study the vegetation the phytosociological method of school Braun-Blanquet (1979) has been followed, updated according to specific studies in the area (Soriano, 1995; Ferrer, 2008; Lourbe, 2006; Silveira et al., 2010; Chamarro et al., 2010).

The plant communities are classified in a syntaxonomical scheme according to the “Checklist of vascular plants Syntaxonomical Communities” by Rivas-Martínez et al. (2001 and 2002). The numbers listed before taxonomic categories correspond to the numbers that have these categories in the Syntaxonomical Checklist (Rivas-Martínez et al., op. cit.).

To determine whether the plant communities found can be included in the Habitats Directive Interpretation Manual (European Commission, 2007), specific publications (Bartolomé et al., 2005) have been used.

A species was considered as invasive in the area when following behaviour was detected:
- in less than 50 years it has established 100 m away from the input focus in case of plants that reproduces by seeds.
- in less than three years it has spread at more than 6 m away from the input focus, if its reproduction is vegetative through rhizomes or stolons (Vilà et al., 2008).

In the absence of data the Atlas of invasive alien plants Spain (Sanz et al., 2004) has been followed.

Several invasive species were not included in the present study, since their presence in the area was not confirmed, although there are literature references about their location near the study area.

Results and discussion

Synthesis of flora and vegetation

Taxonomic analysis
A total of 361 species from 79 families were identified in the area of study. Most of the species are dicots (289), and only few are pteridophytes (2) and gymnosperms (1).

The three most represented families are Compositae (55 species), Gramineae (48), and Leguminosae (22).

Other well represented families after they are Euphorbiaceae (15), Umbelliferae (13), Brassicaceae (11), Caryophyllaceae (10), Labiatae (9) and Chenopodiaceae (9).

---

Fig. 1. Distribution of species
Analysis of biotypes
According to the classification of biological forms by Raunkjaer (1934), we have found 128 therophytes, 90 hemicryptophytes, 35 chamaephytes, 48 phanerophytes, 49 geophytes and 12 water plants. It is worth noting the large number of therophytes, maybe due to ornamental and landscaping gardening.

Analysis of habitat preference
Ruderal environments represent the preferred habitat for the species, and urban roads are significant (52%). These areas are subject to strong human influence.

Also noteworthy is the presence of preference for agroecosystems but with a lesser extent (12%). These ecosystems remain influenced by human being.

As the area of the study is a coastal zone, a large number of species found have a coastal character and live in areas of beach, dunes and coastal wetlands (25%). These habitats are natural ecosystems although they are strongly influenced by human activity. The riparian environment would be in the same case, where there is a significant representation of species.

Biogeographical distribution analysis
Most of the species found are Mediterranean, 124 species of the 361 scheduled. The diverse origin of the different species found is due to the introduction of exotic species. Among these we should mention the good representation of species with tropical origin (about 44 species). It is also important the number of paleotemperates found, 26 of 361. The number of endemic species is relatively low, occurring only 5 species.

Habitats of Network Natura 2000
The list below shows the habitats included in the Habitats Directive found in the territory, both in areas which now have some specific global protection (SCIs, local protected sites) and outside these areas. The priority habitats are marked with an asterisk.

Malcolmietalia dune grasslands. Code: 2230
Association: Erodio laciniati-Maresietum nanae
Crucianellion maritimae fixed beach dunes. Code: 2210
Association: Medicagini-Ammophiletalia australis
Embryonic shifting dunes. Code: 2110
Association: Eryngio maritimi-Sporoboletum arenarii
Association: Cypero mucronati-Agropyretum juncei
Thermomediterranean riparian galleries and thickets Code: 92DO
Association: Tamarietum gallicae
Natural eutrophic lakes with Magnopotamion or Hydrocharition vegetation Code: 3150
Association: Lemnetum gibbae
*Coastal lagoons. Code 1150
Association: Typho domingensis-Phragmitetum maximi

Vegetation
The study area was previously dominated by Mediterranean coastal dunes, which have occupied these decreasing surface area.

The few dunes that lie along the study area have yet part of the biodiversity of flora and fauna that characterize these ecosystems. This is because they represent the interface between the marine habitat and inlands, in which we can find species of great variability and even adapted to extreme conditions of isolation, salinity and other aggressions that present the coastal ecosystem.

An amount of 38 associations and plant communities have been recorded, included in 17 vegetation classes. Of these, 10 are from dune communities, 2 from rocky shore communities or gravel, 11 from coastal and riparian wetlands, 1 from shrub and 14 from weedy and greens communities that are replacing the previous.

Syntaxonomical scheme
12-CL: Phragmito-Magnocaricetea Klika in Klika and Novák 1941
12 a. Phragmitetalia Koch 1926
12.1. Phragmition communis Koch 1926

16-CL: Ammophiletea Br.-Bl. and Tüxen ex Westhoff, Dijk and Passchier 1946
16 a. Ammophiletalia Br.-Bl. 1933


16.1b. *Agropyrenion farcíti* Rivas-Martínez, Costa, Castroviejo and E. Valdés 1980


16b. *Crucianelletalia maritimae* Sissingh 1974

16.4. *Crucianellion maritimae* Rivas Goday and Rivas-Martínez 1958


17.-CL: *Cakiletea maritimae* Tüxen and Preising ex Br.-Bl. and Tüxen 1952


17.2. *Cakilion maritimae* Pignatti 1953

Association: 17.2.3. *Hypochoerido radicatae-Glaucietum flavi* Rivas Goday and Rivas-Martínez 1958

Association: 17.2.4. *Salsolo kali-Cakiletum aegyptiacae* Costa and Mansanet 1981

19.-CL: *Crithmo-Staticetea* Br.-Bl. in Br.-Bl., Roussine and Nègre 1952

19a. *Crithmo-Staticetalia* Molinier 1934

19.1. *Crithmo-Staticion* Molinier 1934


20.-CL: *Juncetalia maritimi* Br.-Bl. in Br.-Bl., Roussine and Nègre 1952

20a. *Juncetalia maritimi* Roussine and Nègre 1952

20.1. *Juncion maritimi* Roussine and Nègre 1952


20.2. *Plantaginion crassifoliae* Br.-Bl. in Br.-Bl., Roussine and Nègre 1952

Association: 20.2.2. *Schoeno nigrantis-Plantaginetum crassifoliae* Br.-Bl. in Br.-Bl., Roussine and Nègre 1952


23b. *Limonieta maritimae* Br.-Bl. and O. Bolòs 1958

28.-CL: *Parietarietalia* Rivas-Martínez in Rivas Goday 1964


34.-CL: *Artemisienea vulgaris* Lohmeyer, Preising and Tüxen ex von Rochow 1951

34a. *Artemisienia vulgaris* 34b. *Agropyretalia repentis* Oberdorfer, Müller and Görs in Oberdorfer, Görs, Korneck, Lohmeyer, Müller, Philipp and Seibert 1967

34.6. *Bromo-Oryzopsion miliaceae* O. Bolòs 1970

Association: 34.6.2. *Centaureo maritimae-Echietum sabulicolae* Costa and Mansanet 1981

Association: 34.6.6. *Inulo viscosae-Oryzopsietum miliaceae* O. Bolòs 1957

38.-CL: *Polygono-Poetea annuae* Rivas-Martínez 1975


38.5. *Euphorbion prostratae* Rivas-Martínez 1976

Association: 38.5.1. *Euphorbietum chamaesyco-prostratae* Rivas-Martínez 1976

39.-CL: *Stellarietalia mediae* Tüxen, Lohmeyer and Preising ex von Rochow 1951

39c. Solano nigri-Polygonetalia convolvuli (Sissingh in Westhoff; Dijk and Plasschier 1946) O. Bolòs 1962
39d. Chenopodio-Stellarietalia Rivas Goday 1956
39d. Chenopodiatales muralis Br.-Bl. in Br.-Bl., Gajewski, Wraber and Walas 1936
39b. Chenopodiion umbellatae-Diplotaxietum erucoidis Br.-Bl. in Br.-Bl., Gajewski, Wraber and Walas 1936
39.8c. Haloschoenetalia vulgaris Br.-Bl. ex Tüxen 1936 ex Tüxen 1937
39c. Holoschoenetalia vulgaris Br.-Bl. ex Tchou 1948
39b. Holoschoenetalia vulgaris Br.-Bl. ex Tchou 1948
39b. Paspalo-Helechloietalia Br.-Bl. in Br.-Bl., Roussine and Nègre 1956
Association: 40.5.2. Cysto-Oxalidetum pedis-caprae O. Bolòs 1956
39c. Potentillo reptantis-Agrostietum trifolio fragiferi-Cynodontion majoris Tüxen ex Rivas-Martínez 1978

56.7. Hyparrhenion birtae Br.-Bl., P. Silva and Rozeira 1956
59.-CL: Molinio-Arrhenatheretalia Tüxen 1937
59c. Holoschoenetalia vulgaris Br.-Bl. ex Tchou 1948
59b. Holoschoenetalia vulgaris Br.-Bl. ex Tchou 1948
Association: 59.7.11. Holoschoenetum vulgaris Br.-Bl. ex Tchou 1948
59b. Paspalo-Helechloietalia Br.-Bl. in Br.-Bl., Roussine and Nègre 1952
59e. Plantaginetales majoris Tüxen and Preisin in Tüxen 1950
59.11. Potentillion anserinae Tüxen 1947
Association 59.11.2. Lolio perennis-Plantaginetum majoris Beger 1930
59.12. Trifolio fragiferi-Cynodontion Br.-Bl. and O. Bolòs 1956
Association: 59.12.7. Potentillo reptantis-Agrostietum stoloniferae O. Bolòs in O. Bolòs and Molinier 1984
Association: 59.12.7. Potentillo reptantis-Agrostietum stoloniferae O. Bolòs in O. Bolòs and Molinier 1984
Association: 59.15.8. Potentillo reptantis-Menthetum suecomens O. Bolòs 1956

50b. Cutandietalia maritimae Rivas-Martínez, Diez-Garretas and Asensi in Rivas-Martínez et al. 2002

56.-CL: Lygeco-Stipetalia Rivas-Martínez 1978
56b. Hyparrhenietalia hirtae Rivas-Martínez 1978

Association: 71.6.1. *Salicetum discoloro-angustifolii*

75.-CL: Quercetum ilicis Br.-Bl. ex A. and O. Bolòs 1950

75b. Pistacia lentisci-Rhamnetalia alaterni Rivas-Martínez 1975

75.5. *Asparago albi-Rhamnion oleoidis* Rivas Goday ex Rivas-Martínez 1975


Invasive species

In the study 49 invasive species have been catalogued:

*Agave americana* L.
*Agave sisalana* (Engelm.) Perrine ex J.R. Drumm and Prain.
*Aloe arborescens* Mill.
*Amaranthus retroflexus* L.
*Amaranthus blitoides* S. Watson
*Aptenia cordifolia* (L. fil.) Schwantes
*Arctotheca calendula* (L.) Levyns
*Arundo donax* L.
*Aster squamatus* (Spreng.) Hieron
*Canna indica* L.
*Carpobrotus acinaciformis* (L.) L. Bolus
*Carpobrotus edulis* (L.) N.E.Bs.
*Conyza bonariensis* (L.) Cronq.
*Conyza canadensis* (L.) Cronq.
*Cortaderia selloana* Ach and Graebn.

*Crassula ovata* (Mill.) Druce
*Cylindropuntia subulata* (Muehlenpfordt) Backeberg
*Disphyma crassifolia* (L.) L. Bolus
*Drosanthemum floribundum* Schwantes.
*Ficus elastica* Roxb. ex Hornem
*Gazania rigens* (L.) Gaertner
*Heliotropium curassavicum* L.
*Ipomoea indica* (Burm.) Merr.
*Ipomoea sagittata* Poir.
*Kalanchoe blossfeldiana* CV.
*Lantana camara* L.
*Ligustrum ovalifolium* Hassk.
*Lonicera japonica* Thunb.
*Myoporum laetum* G. Forst.
*Nicotiana glauca* R. C. Graham
*Opuntia dillenii* (Ker-gawler) Haw.
*Opuntia maxima* Miller.
*Oxalis pes-caprae* L.
*Paspalum distichum* L.
*Pelargonium* spp.
*Pennisetum clandestinum* Chiov.
*Pittosporum tobira* (Thunb.) W.T.Aiton
*Populus x canadensis* Moench
*Ricinus communis* L.
*Seneio cineraria* DC.
*Seneio mikanioides* Otto ex Walp
*Solanum nigrum* L.
*Sorghum halepense* (L.) Pers.
*Stenotaphrum secundatum* (Walter) O.Kuntze
*Washingtonia filifera* (Lindren ex André) H. Wendl.
*Washingtonia robusta* H. Wendl.
*Xanthium italicum* Moretti
*Yucca aloifolia* L.
*Yucca gloriosa* L.

Invasive species

In the study 49 invasive species have been catalogued:

*Agave americana* L.
*Agave sisalana* (Engelm.) Perrine ex J.R. Drumm and Prain.
*Aloe arborescens* Mill.
*Amaranthus retroflexus* L.
*Amaranthus blitoides* S. Watson
*Aptenia cordifolia* (L. fil.) Schwantes
*Arctotheca calendula* (L.) Levyns
*Arundo donax* L.
*Aster squamatus* (Spreng.) Hieron
*Canna indica* L.
*Carpobrotus acinaciformis* (L.) L. Bolus
*Carpobrotus edulis* (L.) N.E.Bs.
*Conyza bonariensis* (L.) Cronq.
*Conyza canadensis* (L.) Cronq.
*Cortaderia selloana* Ach and Graebn.

*Crassula ovata* (Mill.) Druce
*Cylindropuntia subulata* (Muehlenpfordt) Backeberg
*Disphyma crassifolia* (L.) L. Bolus
*Drosanthemum floribundum* Schwantes.
*Ficus elastica* Roxb. ex Hornem
*Gazania rigens* (L.) Gaertner
*Heliotropium curassavicum* L.
*Ipomoea indica* (Burm.) Merr.
*Ipomoea sagittata* Poir.
*Kalanchoe blossfeldiana* CV.
*Lantana camara* L.
*Ligustrum ovalifolium* Hassk.
*Lonicera japonica* Thunb.
*Myoporum laetum* G. Forst.
*Nicotiana glauca* R. C. Graham
*Opuntia dillenii* (Ker-gawler) Haw.
*Opuntia maxima* Miller.
*Oxalis pes-caprae* L.
*Paspalum distichum* L.
*Pelargonium* spp.
*Pennisetum clandestinum* Chiov.
*Pittosporum tobira* (Thunb.) W.T.Aiton
*Populus x canadensis* Moench
*Ricinus communis* L.
*Seneio cineraria* DC.
*Seneio mikanioides* Otto ex Walp
*Solanum nigrum* L.
*Sorghum halepense* (L.) Pers.
*Stenotaphrum secundatum* (Walter) O.Kuntze
*Washingtonia filifera* (Lindren ex André) H. Wendl.
*Washingtonia robusta* H. Wendl.
*Xanthium italicum* Moretti
*Yucca aloifolia* L.
*Yucca gloriosa* L.
Most of the exotic species found have an American or African origin. In this second case, most of them come from South Africa. It is also important the large number of invasive, as it is shown in Fig. 3:

![Fig. 3. Invasive species origin](image-url)
species with a tropical origin. This shows the great ability of our country to host thermophilous species.

To find the causes of the presence of invasive species a study of its mode of introduction has been made, reaching the following results:

Gardening is the most important way of introduction (76% of introduced species) of ornamental species that escaped from culture and became naturalised, with more or less success. This is due mainly to the development of gardening based almost exclusively on the use of exotic elements instead of using autochthonous species, much more advisable, as the native flora is well adapted to our environmental conditions and includes taxa with ornamental potential as well. (Sanz Elorza et al., 2004).

On the other hand, introductions made by chance increased due to the development of trade and tourism in recent years.

3. Relation between invasive species and autochthonous plant communities

It is important to know the concentration or abundance in which we can find the invasive species and their growing area approximately. The locations of the most representative species have been mapped and the surface which they occupy was calculated. Also it has been proved that native plant communities were invaded by the species. The monitoring was carried out in communities considered autochthonous, since most of their species are native. The results are shown in the following table:

Species that are able to colonize plant communities of different ecosystems present in this zone are:

- **Carpobrotus edulis**
- **Agave spp.**
- **Arundo donax**
- **Yucca spp.**
- **Nicotiana glauca**
- **Opuntia spp.**
- **Cortaderia selloana**

Furthermore, the associations that present higher number of invasive species are:

- **Centauro maritimae-Echietum sabulicolae**
- **Medicagini marinae-Ammophiletum australis**
- **Asphodelo fistulosi-Hordeetum leporini**
- **Cypero mucronati-Agropyretum juncei**
- **Parapholido incurvae-Catapodietum marini**

The abundance of **Carpobrotus edulis**, coming to occupy nearly 30,000 m² (46%) and dispersed throughout the study area. In the same situation is **Arundo donax**, which occupies almost 23,000 m² (36%). In this second case **Arundo donax** was found further away to the mainland, but **Carpobrotus edulis** is covering the dunes themselves, causing serious issue on vegetation.

**Carpobrotus edulis** in many cases is accompanied by other invasive species as **Yucca gloriosa** (2000 m²) and **Agave spp.** (11% of land area covered by invasive species).

With the species represented in the chart above, the total 63,961 m² area occupied by invasive species. This measure may change due to their rapid proliferation.

**Conclusions**

The potential natural vegetation has decreased its distribution area, which has modified its syntaxonomic composition with an increase in ruderal and weed communities, so that 38 of the present associations, 14 of them are weedy and greens communities. The results shows that invasive species are able to penetrate, both in the vegetal coastal communities and the nitrophile communities that substitute them. Of the total surface of the study area 4% is covered by invasive species. This is an considerable invasion level, seeing that the dunes communities have few vegetal coberture. Moreover, it has an strong landscape impact. It is not simply particular biological characteristics that determines invasiveness (Kueffer et al., 2010). The paper of the human being as propagator element is very important, like in other parts of the world (Trueman et al., 2010).

However, the presence of 14 habitats from the Habitats Directive proves the high ecologic value that the area
has. For the conservation and recovery is prioritary the invasive plants eradication (specially the *Carpobrotus*, *Yucca*, *Agave*, *Opuntia* and *Cortaderia* genus), and the control of populations of *Arundo donax*, with the land use ordenation, in order to prevent the vegetation trampling and soil degradation.

**Acknowledgements**

This study is part of a project to study the coast by the UPV and directed by Jose Serra, has been sponsored by government institutions (General Directorate of Coasts, Ministry of Environment (“Ministerio de Medio Ambiente y Medio Rural y Marino”) and Wildlife Service of Valencia Regional Government (Generalitat Valenciana, the Local Government of the Valencian region). We thank Juan Gimenez and Javier Ranz, the servicing of your support for this project.

**References**


