

Libro de resúmenes / Livro de resumos

Reuni3n Ib3rica Sobre Plantas Invasoras

rumo a uma estrat3gia de investigac3o convergente

PLANTAS INVASORAS

hacia una estrategia de investigaci3n convergente



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FOREWORD

En la 1ª Reunión Ibérica sobre Plantas Invasoras hemos conseguido reunir a **científicos de campos diferentes**, pero estrechamente vinculados, botánicos, ecofisiólogos, ecólogos, edafólogos e economistas para intensificar el esfuerzo en la realización de actividades y uso de **metodologías convergentes** en el estudio de los mecanismos que conducen a la invasión de especies vegetales.

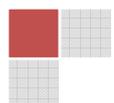
Hasta ahora, los grupos de investigación ibéricos que trabajan en invasión vegetal: impacto sobre la diversidad biológica, resistencia a la invasión, variaciones en la relación suelo-planta, no han trabajado en estrecha colaboración, a pesar de que las áreas de investigación están fuertemente vinculadas. Una mayor interacción que permita integrar estudios y metodologías diferentes bajo un objetivo común, podría mejorar significativamente el **avance** en la comprensión de los rasgos y mecanismos que regulan la invasión por especies vegetales exóticas.

Un saludo y bien venidos a la 1ª, que no última, Reunión Ibérica sobre Plantas Invasoras.

Na 1ª Reunião Ibérica sobre Plantas Invasoras conseguimos reunir **investigadores de diversos domínios** científicos, mas estreitamente relacionados, como botânicos, ecofisiólogos, ecólogos e edafólogos e economistas de forma a convergir esforços na realização de actividades e uso de metodologias comuns no estudo dos mecanismos que conduzem à invasão por espécies vegetais.

Apesar das diferentes áreas de investigação estarem intimamente relacionadas, até ao momento, os grupos de investigação ibéricos que se dedicam ao estudo das invasões vegetais (e.g., impacto sobre a diversidade biológica, resistência à invasão, variações na relação solo-planta) não têm trabalhado em estreita colaboração. Uma maior interacção entre equipas de investigação permitirá integrar diferentes estudos e metodologias sob um objectivo comum e melhorar significativamente o **avanço** científico sobre as características e mecanismos que regulam a invasão por espécies vegetais exóticas.

Cumprimentos e bem vindos à 1ª, que não última, Reunião Ibérica sobre Plantas Invasoras.



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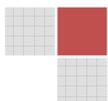
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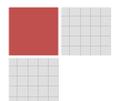
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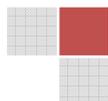
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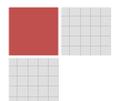
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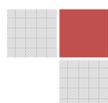
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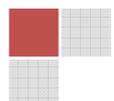


Environmental volunteer role in non-native invasive plants elimination

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ADEGA (*Asociación para a defensa ecolóxica de Galiza* - Association for the ecological defense of Galicia) & *Proxecto Ríos* (Rivers Project) consider essential the work with and for citizenship, when it comes to socio-environmental issues such as non-native and invasive species. That's why because it is important to study, prevent and act as soon as possible in this matter. For these reason we've worked since 5 years ago in spreading and development projects in this field. The methodology used in the environmental volunteer activities is based in action-investigation (or participative investigation), and pretends that volunteers would learn by doing (recognized learning methodology), combining theories, opinion and experts proposal with volunteer work. ADEGA has developed several projects in different natural and urban ecosystems (rivers, dunes, coastal lagoons, universities campus gardens, etc.) and different non-native and invasive plants species (*Acacia dealbata*, *Arundo donax*, *Carpobrotus edulis*, *Cortaderia selloana*, *Cyperus involucratus*, *Oxalis pes-caprae*, *Phyllostachys* spp., *Phytolacca americana*, *Tritonia x crocosmiiflora*, *Zantedeschia aethiopica*, etc.). Most of the volunteer works are continued in time, like the *Environmental Volunteer Field* in Tea River or in Corna Beach, with duration of 4 and 3 years respectively. Priority is given to projects for removal of non-native flora with the participation of volunteers, in which: a) places are easily accessible, b) the bio-invasions are incipient, and c) they allow to test new elimination methodologies and get relevant results. These actuaciones allow spread and make the population aware. At the same time they permit direct social involvement in natural place recovery. We understand that it is essential for a greater attention by management to conduct information campaigns on the reality of this problem, through projects involving Environmental Education and Environmental Volunteers.



Alien plant monitoring with ultralight airborne imaging spectroscopy

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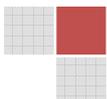
Monitoring invasive plants to delineate their spatial extent and spreading patterns is essential to effectively manage them. In large areas with difficult access, physical and economical impediments prevent adequate spatial and temporal resolutions unless remote sensing is used.

Passive optical remote sensing techniques are based on the analysis of the reflection spectra of different objects in the landscape, which differ depending on their biochemical and structural properties. This allows the discrimination of different land covers in an image (e.g. forests, bare ground, etc.). However, the spectral signature of different plant species is very similar, and most remote sensing techniques are not able to distinguish between species. High spatial and spectral resolutions are needed for this task. Hyperspectral imaging has proved to be useful when a high degree of detail is needed for discrimination. However, its high cost makes it prohibitive for routine use in environmental applications, except for the largest agencies.

We have developed an airborne hyperspectral sensor with 200 spectral bands [350, 1000 nm], and submetric spatial resolution, to assess the potential of this technology for invasive plant monitoring in national parks of Spain. The sensor is deployed on board an ultralight platform with very low operation and maintenance costs, adding asset to the effectiveness of the technology. To test the suitability of the technology, we used the following species: *Acacia* spp., *Carpobrotus* spp., *Oxalis pes-caprae* and *Arctotheca calendula*, which differ in size, growth patterns and spectral properties, and thus have been used as model species. Using Support Vector Machines (SVMs) and Sparse Representation-based Classification (SRC) we have obtained good results with *Acacia* spp., *Carpobrotus* spp. and *Oxalis pes-caprae*, exceeding 90% overall detection accuracy and less than 5% false positives. Detection of *Arctotheca calendula* was unfeasible when appearing in small patches, well below the system spatial resolution, which can still produce large numbers of seeds and favor the spreading of the plant.

The possibility to perform periodic hyperspectral scanning of protected areas at low operational cost does not only offer improving management of plant invasions but also allows an extensive archive of detailed spatio-spectral information, which can be used in the long run for many different management tasks (not specifically related to plant invasions) such as causal analyses of adverse ecosystem dynamics, as reference data for restoration after catastrophic events, or for short- and long-term monitoring and modulation of management measures.

Keywords: remote sensing, plant invasion monitoring, mapping techniques.



Do *Eucalypt* plantations contribute to maintain the biodiversity of our native forests?

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In many countries, plantation forestry depends on a few fast-growing exotic species, which often have important ecological impacts, which can be reduced with appropriate management.

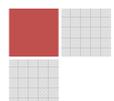
Eucalyptus globulus has been intensively cultivated in different areas of the Iberian Peninsula. In Galiza (NW Spain), *E. globulus* area has multiplied by 6 in the last 25 years, both by intentional planting and natural spread in adjacent communities. In this study we analyze the contribution of eucalypt plantations to regional biodiversity. We compared understory plant diversity and species composition in 6 types of communities (5 replicates per community, with 10 plots per replicate): Eucalypt plantations of three different ages: (1) 5-8 yr (young), (2) ca. 15 yr (intermediate, ready for harvest) and (3) > 20 yr (mature, left unharvested after optimum harvest time, with low-intensity management), (4) *Pinus pinaster* plantations (harvest size), (5) native forests of *Quercus robur* (mature age), and (6) native shrublands (dominated by *Ulex* spp. and *Erica* spp.).

In eucalypt plantations, species richness (S) was highest in young plantations (38 spp.), lowest in intermediate (19), and increasing again in mature plantations (34). Diversity in intermediate eucalypt plantations was lower than in other communities, but, when comparing young and mature eucalypt plantations, biodiversity levels were similar to those of native forests and pine plantations (S = 38 and 30 in these communities).

Native forests were not clearly more diverse than plantations. However, looking at the species composition, we did find important differences that make native forests unique. They were significantly different to all other communities (pairwise tests: $t > 2.3$, $P < 0.004$, PERMANOVA, with Bray-Curtis similarity matrix, 9999 permutations). Eucalypt plantations were most similar to shrublands when young, although impoverished in species, diverging from them as they grow older. Native communities (forests and shrublands) had the highest number and proportion of unique species (>50%, whereas plantations had <10%). Native forests harbored most of the fleshy-fruited plants recorded, which interact with frugivorous vertebrates for seed dispersal. Moreover, the most severe types of rarity were also associated with native forests.

Plantations do not contribute significantly to the maintenance of the biodiversity of our native forests, which conservation is necessary to preserve our regional biodiversity.

Keywords: biodiversity patterns, exotic tree plantations, forestry.



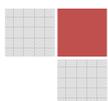
Azolla in the Iberian Peninsula: causes, consequences and a management strategy for its control

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Azolla, a heterosporous floating pteridophyte, which contains a nitrogen fixing cyanobacterium, was introduced in Europe in the mid-XIX century as an ornamental plant, and quickly spread into the nature. It was first identified in the Iberian Peninsula in the Botanical Garden of Madrid in 1907 by Manuel Rodríguez López-Neyra, and was collected in Portugal for the first time in 1920 at the Alcácer do Sal region, by Luiz Fernandes of the Botanical Garden of Lisbon (LISU). In Europe two species have been referred to, *A. filiculoides* and *A. caroliniana*, although in Portugal recent studies only mention the first species. It has been identified in river basins of several Portuguese and international rivers, such as the Vouga, Coa, Mondego, Tejo, Sado and Guadiana. Due to the climatic changes (e.g. subtropicalization of South of Europe) and high nutrient concentration, namely phosphorus present in water bodies, *Azolla* has spread, being present almost in all of the Iberian Peninsula. In the last two decades, several major blooms occurred in diverse regions of Portugal and Spain, linked by the presence of higher phosphorus concentration in the water bodies presented in those regions, with serious consequences to the ecology and economy. In this communication we highlight three *Azolla* major blooms in the years of 1993 and 2009 in the international rivers Guadiana and Tejo and also in the Donãna National Park during the years 2001 to 2003. A transnational programme for *Azolla* control, integrated in a European Observatory for weeds management is proposed.

Keywords: *Azolla*, blooms, Iberian Peninsula, management control.

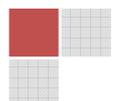


Invasive risk assessment of exotic trees: distribution patterns, invasive success and impact on ecosystems

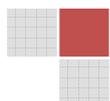
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Exotic invasive species may notably alter ecosystem functions and decline the quality of environmental services. During the last two centuries, several exotic tree species, such as *Ailanthus altissima* (Mill.) Swingle, *Robinia pseudoacacia* L., *Ulmus pumila* L., *Acacia dealbata* Link, *Acer negundo* L., etc, have naturalized in the Iberian Peninsula, some of them threatening native riparian woodlands. However, there is a lack of information on the factors controlling exotic tree species distribution, population trends, functional strategies and ecosystem impacts. Filling these gaps is the aim of a multidisciplinary team joining the efforts of ecologists, zoologists, chemists and land managers of different institutions across Spain. Our specific objectives are: 1) mapping the distribution of exotic tree species in the floodplains of three areas in Spain, contrasting in climate and human pressure; 2) identifying the strategies explaining the success of exotic trees; and 3) assessing the impacts of exotic trees on the functions of affected aquatic and terrestrial ecosystems. Regarding the first aim, we are conducting a systematic sampling of exotic tree populations in the Southeast Natural Park (Madrid), in the Henares River floodplains (Guadalajara and Madrid provinces), in the middle Ebro River floodplains (Zaragoza province) and in the Oria river basin (Gipuzkoa province). Preliminary results on *A. altissima* in the Henares River suggest that this species is highly favoured by human disturbance and it is successfully spreading through areas close to the river, roads, paths, railways and/or towns, although some patches are also invading natural riparian vegetation. Regarding the factors that explain exotic tree success, a wide study on Australian *Acacia* spp. indicated that high water availability and climatic amplitude in the native range, high number of human uses, and high values of a life-history index (proportional to plant height, leaf area and seed mass) contribute to predict the probability of this group of species being invasive. Besides, we are conducting fieldwork to check the hypotheses that some exotic trees in central Spain floodplains are successful invaders because of their high seed production, seed emergence rate, resprout ability, seed dispersal ability, growth rate and ability to produce aerial and soil seed banks. The preliminary results indicate that there is no single life-history strategy explaining the success of different exotic trees. Concerning the impacts of exotic trees on the invaded native ecosystems, we found that litter decomposition rates tend to be slightly lower in exotic than in coexisting native trees, mostly because of the higher proportion of secondary compounds in the former. The impacts of exotic litter on soil properties widely vary in extent and direction among species. Among the studied species, the most impacting litter was that of *Eucalyptus globulus* Labill, which drastically dropped the pools of mineral N in the soil and the nitrification processes. We are currently assessing how



the litter of different exotic tree species alters the structure of macroinvertebrate communities dwelling in freshwater streams and soils receiving this litter. By merging the results of the three aims we will be able to assess the risk of exotic trees naturalized in different parts of Spain to terrestrial and aquatic ecosystems.

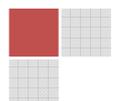


Habitat risk assessment of invasion by alien plants: landscape analysis and future scenarios (RIXFUTUR Project)

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Under current global change the invasion of natural habitats by alien species constitutes an important factor affecting the ecologic and economic value of most ecosystems. In this project we propose a biogeographic study of plant invasions at the landscape level on the factors associated to the degree of invasion in terrestrial habitats. Such approach will be in accordance with the needs of natural resources managers in their assessments of invasion risk in natural areas. The specific goals of the project are (1) to estimate the degree of similarity in plant invasions of equivalent habitats among different Mediterranean areas, (2) to explore the relationship between the local presence and abundance of invasive species and the structure of the landscape, and finally (3) to evaluate the specific habitat vulnerability to plant invasion under future climatic and landscape scenarios. One of our proposed hypotheses is: the structure of the landscape affects the success and spread of invasions. The methods used in the project include the use of large databases and extensive field surveys. Such combination of data will allow us to take into consideration that most invasive species are not in equilibrium with the environment, and that their current distributions may not reflect their total capacity for invasion, and thus will help us to assess what their full invasive potential could be. Here we present one data set we are currently working with regarding plant invasion in southeast Spain coastal habitat. We also present preliminary result about native plant assemblages in invaded and non-invaded sites.

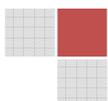


Phenological development and ecophysiology performance of the exotic *Acacia longifolia* under different climatic conditions

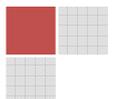
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Several species of *Acacia* are noxious weeds in many parts of the world, especially in Mediterranean climate regions. In Portugal, *Acacia longifolia* is one of the most aggressive invasive plant species and causing major ecological problems. The objective of this study is to understand the ecophysiological response of *A. Longifolia* to different climatic conditions and to understand how different climatic conditions can affect vegetative and reproductive investments of this invasive species. The study was conducted at two different sites, north and south of Lisbon, where there are different climate conditions, being Meso-Mediterranean with an Atlantic influence in the north and typically Mediterranean in the south. Both sites consist in an interior dune typically occupied by a *Pinus pinaster* plantation, and they are infested with *A. longifolia*. In each plot they were performed leaf water potential and gas exchanges measurements in *A. longifolia*, in three occasions: March, June and July. Additionally, stable isotopes of leaf were also performed. Phenology was monitored by measuring shoot elongation and by counting leaves, flowers and fruits. Then, a phenological diagram was elaborated. Although the more mesic conditions in the north site, the results pointed out no differences in leaf water potential between sites, and also no difference in carbon isotopic signature of bulk leaf. While in the north the more drastic decrease in gas exchange occurred from June to July, in the south a greater decrease occur earlier, from March to July. However, plants of *A. longifolia* in the north site were more sensitive to the drought period, displaying lower values of A and g_s than the southern plants. In addition, plants in the north site had an averaged delay from 20 to 30 days in all phenophases. Significant differences between the study sites appeared in the magnitude of growth and in the flower and fruit productions. In the northern *A. Longifolia* showed higher reproductive investment and lower growth rate compare to southern forest. In this work we presented evidence that carbon balance and water fluxes of *A. Longifolia* were affected by stressful climatic conditions. Furthermore, the climatic differences between northern and southern locations may be responsible for different patterns in A and g_s in *A. longifolia*. The present study suggests that higher air temperatures and irradiance may cause earlier display of phenological phases in the southern than in the northern plants. Moreover, the phenological study provides further evidence of the trade-offs between reproductive and vegetative investment in *A. Longifolia* under habitats with limited resources. Forest systems in the north of Portugal, with more mesic conditions but relative higher biomass and higher resources competition might be more stressful for *A. longifolia*, displaying a lower physiological performance and higher reproductive costs than in the south forests systems. These results are especially important to understand the factors that can determine the reproductive costs in *A. longifolia*, emphasizing potential differences in the invasive pattern according to the climatic conditions. Moreover, this study may contribute for a future model that will account climate change scenarios and invasiveness patterns in the Mediterranean region.



Keywords: *Acacia longifolia*, forest systems, gas exchanges, phenological trade-offs, vegetative growth, reproductive costs.

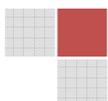


Modelling the current distribution and forecasting the future dynamics of three alien invasive woody plants in the north of Portugal

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Biological invasion is growing as one of the main promoters of biodiversity loss worldwide, and Portugal is not an exception to this trend. Invasions by alien species are through to be enhanced by changes in climate and disturbance regimes, as well as by other environmental shifts. Preserving native biodiversity and ecosystems from the effects of biological invasions thus requires a number of comprehensive studies and measures to anticipate impacts and protect the species and habitats that are supposedly at higher risk. One possible approach to this challenge assesses the potential of invasion by alien invasive species in a certain region, both for present conditions and under scenarios of future environmental changes. In this research, we modelled the distribution of three invasive alien plant species (all belonging to genus *Acacia*) in Northern Portugal, in order to predict and explain their current regional distribution, and to forecast possible impacts of climate change scenarios in that distribution. For this, we developed a combined predictive modelling (CPM) approach to assess the current status and future dynamics of those alien species, based on fitting species distribution models (SDMs) using subsets of predictors previously classified as acting at regional or local scales. This *a priori* classification of environmental factors is based on a combination of ecological theory and spatial statistics, as discriminates the effects of such drivers as climate, soils, land use or landscape structure according to their scale of influence on species distributions. As demonstrated in previous research, these combined models predict a wider variety of potential species responses, providing more informative projections of species distributions and dynamics than traditional, non-combined models. Therefore, by adopting this approach to model the current and future distribution of three major alien invaders in the region, this research will: a) identify the areas potentially most affected by invasions, to simulate climate change impacts in the region, b) compare the potential distribution of the invasive species with the distribution of the protected areas in the region, and c) support the development of an optimized monitoring scheme targeted at detecting patterns of invasion and their impacts on regional biodiversity and ecosystems.



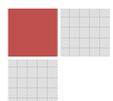
Invisible invasion: soil behaviour behind the arrival of *Carpobrotus edulis* (L.) N.E.Br.

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For many Mediterranean climate countries, *Carpobrotus* taxa is designated as one of the exotic plant species to be concern of, due to its invasiveness and difficulty of restoring the invaded environment. We focus in *Carpobrotus edulis*, that is strong invasive plant and it can make vigorous and harmful hybrids. We know that during the invasion process of this non-native plant there are some changes in the soil and its native biota. Although it is supposed that sand is an inhospitable place for the microbial activity, we registered effects in the sand biota. We studied soil modifications by *C. edulis* in two coastal areas in Northwest of Spain, in a primary active dune mainly characterized by *Malcomia littorea* (L.) R.Br.Aiton, *Scrophularia frutescens* L., and a secondary fixed dune with a greater species richness, mainly *Juncus maritimus* Lam. and other different exotics. In this area there are several artificial depressions that are regularly occupied by sea water. Ecological impacts are evaluated through elemental soil analysis, soil pH, electric conductivity and soil microbial biomass carbon as indicators of soil quality; on the other hand, we measure the activities of five soil enzymes (β -glucosidase, acid phosphatase, glicin-aminopeptidase, N- acetilglucosaminidase and urease) as a useful indicator of soil microorganisms function. These results provide evidences of soil physical changes and different alterations in the role of soil biota activity. It is important to elucidate the function of the soil microorganisms in the invasion process of *C. edulis* to establish correctly the ecology of foodwebs and optimize the restoration process after remove exotic plants.

Keywords: acid phosphatase, *Carpobrotus edulis*, enzymatic activities, glicin-aminopeptidase, microbial biomass carbon, N- acetilglucosaminidase, soil biota, soil invasion, urease, β -glucosidase.



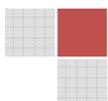
Evolutionary changes to reproductive systems during the invasion process of the polyploid *Oxalis pes-caprae*

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Biological invasions have long been recognized to comprise significant ecological and evolutionary consequences, both for the species and communities being invaded, as well as for the invasive species themselves. The establishment and spread of an invasive species in a new place depends on different evolutionary and ecological pressures and traits linked with production, dispersal and genetic composition of propagules will play a special role. Because reproductive strategies determine demographic and genetic characters of the invasive populations, variations on reproductive characters have the potential to influence evolutionary processes during invasion and the invasion process itself. Therefore, comparative studies of reproductive systems in native vs. invaded ranges are crucial for understanding the biology and mechanisms of plant invasions, for predicting microevolutionary changes in anthropogenic environments, and ultimately, for designing effective control measures for invasive species. However, the roles played by reproductive modes in the successful invasion of exotic species are largely unknown. In this project we use *Oxalis pes-caprae* L. (Oxalidaceae) as model species to study how evolutionary changes in the new range may trigger invasion, in particular, the evolutionary shifts in reproductive systems. The main goals are: (1) to assess the evolution and contribution of asexual and sexual reproduction components in the dynamics of the invasion of *O. pes-caprae* in the Iberian Peninsula, in comparison with the processes acting in the native area; (2) to determine the origin of new cytotypes and floral morphs in invasive populations; (3) to study the impact of the newly established mutualistic interactions in the reproductive success of invasive populations in comparison with native interactions, and to assess the effects of *O. pes-caprae* in the receptive ecosystem, namely on the native plant-pollinator networks; (4) to raise public awareness about the ecological (and economical) impact of invasive species. Our team will gather information based on field observations, common garden experiments and cytological and molecular tools, in both the native and invaded regions, that, altogether, will enable the successful accomplishment of the proposed objectives. The results of the present project will add important background information on the ecologic and evolutionary processes of biologic invasions.

Keywords: biological invasions, microevolution, polyploidy, reproductive strategies.



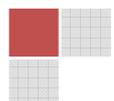
Invasive *Acacia melanoxylon* R. Br. inhibited carbon isotope discrimination and leaf water status in three C₃ perennial forest species

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Invasive plants threaten the persistence of native assemblages, change the composition of plant communities and alter ecosystem functioning. *Acacia* species were introduced in Southern Europe as an ornamental plant in the 19th century; naturalized in the local habitat and slowly become invasive species in Atlantic climates and Mediterranean regions from Portugal to Italy. *Acacia melanoxylon* R. Br. is a naturalized Australian species that has invaded woodlands and degraded natural habitats in the northwestern Iberian Peninsula (Galicia) in Spain. Several phenolic (*p*-hydroxybenzoic, vanillic, *p*-coumaric, syringic, protocatequic, ferulic acids) and flavonoids (catechin, luteolin, rutin, apigenin, and quercetin) were identified from methanol extracts of flowers and phyllodes of *A. melanoxylon* by HPLC. In bioassays, flowers and phyllodes of *A. melanoxylon* were soaked separately in the water in a ratio of 1:1 (w/v) for 24 h to prepare aqueous extracts and distilled water was used as control. The seeds of three native species, *Dactylis glomerata*, *Lolium perenne*, *Rumex acetosa* and a crop *Lactuca sativa* were grown in perlite culture and aqueous extracts of *A. melanoxylon* (flowers and phyllodes) were applied exogenously at various concentrations. Leaf fresh weights of *L. perenne*, *D. glomerata*, and *L. sativa* were reduced after treatment with extracts of acacia flowers and phyllodes at all concentrations. *A. melanoxylon* (flowers or phyllodes extract) decreased root fresh weight of *D. glomerata*, *L. perenne* and *L. sativa*. Leaf relative water content of *D. glomerata* and *L. perenne* was reduced after treatment with acacia flowers and phyllodes extract (100%, 75%, 50%, 25%). *A. melanoxylon* flower aqueous extract (100%) had a dominant effect on carbon isotope ratios ($\delta^{13}\text{C}$) that was significantly less negative in *L. perenne*, *D. glomerata* and *L. sativa* as compared to the control. In the *L. perenne* seedlings treated with *A. melanoxylon* phyllodes aqueous extract (100%), the $\delta^{13}\text{C}$ ratio was significantly less negative (-29.7) as compared to control (-30.6). Carbon isotope discrimination ($\Delta^{13}\text{C}$) values in *D. glomerata* were significantly decreased by acacia flower (100%) extract as compared to the control.

Keyword: *Acacia melanoxylon*, carbon isotopes discrimination, growth, invasion, native species.



Does allelopathy influence the loss of biodiversity in *Acacia dealbata* understorey?

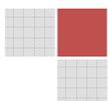
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Allelopathy has been suggested as one of the reasons for the success of the invasive *Acacia dealbata* Link. However, the relative importance of chemical interference and competitive interactions remains unknown. We designed a new technique, called the 'slope box technique', in order to investigate the role of allelopathy in the spread of *A. dealbata* taking into account competitive interactions. In each slope box, four adult *A. dealbata* plants were planted in the middle and four target species (*Dactylis glomerata* L., *Plantago lanceolata* L., *Taraxacum officinale* Weber ex F.H.Wigg and *Trifolium pratense* L.) were sown in transects from the acacia plants towards each end of the box. The rationale of this technique is based on allelochemicals moving together with the soil solution along a slope. We expect that plants in the lower part of the slope will be more affected than plants on the upper part of the slope. The germination of *P. lanceolata* and *T. pratense* was faster close to *A. dealbata*. For three of the four species tested, the photochemical efficiency of photosystem II increased with time in plants grown closer to *A. dealbata*. Interestingly, the aboveground biomass of *P. lanceolata* and *T. officinale* was lowest in plants close to *A. dealbata*, followed by the plants grown on the first part of the lower side of the slope, and highest in plants on the top and bottom of the slope. We concluded that *A. dealbata* seems to release organic compounds that act as allelochemicals on the germination and growth of species nearby acacia, although the interaction of other factors should not be discarded. We also suggest that the 'slope box' technique is a promising method for the study of allelopathy. However, this method should be improved in order to become a powerful tool for discriminating the allelopathic process from other competitive mechanisms in the invasion process.

Keywords: *Acacia dealbata*; Competitive interactions; Invasive species; Native species; Physiological parameters; Slope box technique

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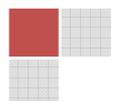
Managing invasive plant species in Portugal: from prevention to biocontrol. The case study of *Acacia longifolia* (INVADER)

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In the last years, we have been studying impacts and restoration of dune ecosystems invaded by *Acacia longifolia* (Andrews) Willd. and the potential use of biocontrol as part of a management strategy. Results show significant impacts of *A. longifolia* at soil, vegetation and seed bank levels. After removal of the invader native communities slowly recover, but pre-invasion conditions are hard to achieve and the areas are quickly re-invaded mainly due to seed germination. This means that a sustainable management strategy needs to consider how to deal with the accumulated long-lived seed bank. *A. longifolia* is successfully controlled in South Africa by the biocontrol agent *Trichilogaster acaciaelongifoliae* Froggatt, an Australian gall-forming wasp that greatly reduces seed production; since its release, more than 20 years ago, seed production of *A. longifolia* has decreased 85-100% and there were no direct non-target effects. However, biocontrol for invasive plants is not yet an option in Portugal, and has only recently been used in other European countries, partially due to concerns relative to non-target effects. In Portugal, thousands of Euros have been spent to control *A. longifolia*, using chemical and mechanical methods, with little success, mainly due to the species' prolific seed bank. In order to provide a sustainable and cost-effective alternative for the control of this species, we have been studying the potential use of *T. acaciaelongifoliae* in Portugal. Results from specificity testing (non-target direct effects), in quarantine, are promising as showed that the agent was not able to complete its life cycle in any of the non-target species tested. Nevertheless, recent studies using food-webs showed indirect non-target effects of other biocontrol agents post-release. As far as we know, indirect non-target effects of a biocontrol agent have never been estimated pre-release; at this stage we have the unique opportunity to make such an assessment. In this context, our future strategy includes using plant-herbivore food-webs to assess the potential indirect non-target effects of *T. acaciaelongifoliae*, before actual introduction, and to evaluate impacts of *A. longifolia* on food-webs. Even if biocontrol indirect effects are proven, they have to be weighed against the negative impacts already caused by *A. longifolia* (risk-benefit analysis) – in the end biocontrol may prove to be a risk well worth taking. From a management point of view, to invest in control without considering prevention and early-detection makes no sense. Therefore, other major goals include start implementing an early-detection program, and continuing our commitment to increase public awareness in order to prevent further invasions.

Keywords: invasive plant species, biological control, food-webs, non-target effects, early-detection, *Acacia longifolia*



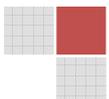
Biomass equation for *Acacia longifolia* (Andrews) Willd. in Portugal

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The main objective of this study was to calculate a practical equation for estimating aboveground biomass of *Acacia longifolia*, one of the most important invasive species in the Portuguese dune ecosystems. For this purpose, eighteen plants were destructively harvested in the São Jacinto Dunes Natural Reserve, located at the central-northern coast of Portugal (40° 39'N, 8° 44'W). Regression analyses were used to examine the relationships between aboveground biomass and five morphological variables measured at each plant (total height, diameter at the base, crown width, depth of the crown and number of stems). The results showed that correlations between aboveground biomass and diameter at the base produced the best significant relationship with the highest R². Power model based on diameter at the base provided the best estimate for aboveground biomass (R² = 0.988, R²_{adj} = 0.975, S_{y,x} = 0.410).

Keywords: *Acacia longifolia*, aboveground biomass, allometric equations, destructive sampling



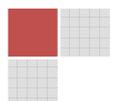
Black wattle (*Acacia mearnsii*) invasion in Galicia: the role of new road infrastructures

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Black wattle *Acacia mearnsii* was recorded for the first time in Galicia in 2003. However, new individuals have been found, allowing to date its presence to the mid-twentieth century, having gone unnoticed during that time by botanists and researchers, probably due to its resemblance to *A. dealbata*. During the flowering season of 2009 and 2010, the distribution area of *Acacia mearnsii* in Galicia (NW Iberian Peninsula) was determined. We located ten population centers in the vicinity of the Rias Baixas, occupying approximately 22.27 ha. The main affected area is the Morrazo Peninsula, which is a major expansion of its area of occupancy in the last five years, tripling the number of 1x1 km UTM where it had been recorded. This expansion process is linked significantly with the opening of new road infrastructures, possibly through transport of seeds or rhizome fragments during the construction of the Via de Alta Capacidade do Morrazo, built between 2003 and 2005.

Keywords: *Acacia mearnsii*, distribution, Galicia, invasion, road infrastructures



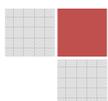
Competitive relationships between two native species of dune (southwestern coast of Galicia-Spain) and the invasive species *Carpobrotus edulis* (L.) N.E.Br.

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Carpobrotus edulis is an invasive species in coastal areas disturbed by intense human use. Nowadays *C.edulis* invades coastal habitats in many parts of the world. We tested the competitive interactions established between the invasive species *C.edulis* and the two native species *Malcomia littorea*(L.) R.Br. and *Scrophularia frutescens* L. The experiment is based on the replacement series design (de Wit, 1960). Density is not considered in the classic design, so we modified this design to have monocultures of different plant densities, thus being able to assess the effect of intraspecific competition. Because of possible residual effects on the dune soil (Arenosol) produced by the invasion of *C. edulis*, competitive conditions were established in soil from invaded areas, and soil from areas without invading. We used two indexes to quantify the intensity of competition (RSC and RII) and two indexes to quantify the effect of competition (RLO and RRT). Different indexes are discussed in relation to the capacity *C. edulis* to invade new areas.

Keywords: *Carpobrotus edulis*, invasion, Replacement series, Competition indexes.



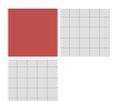
Seeds are also competing. Effect of *Carpobrotus edulis* (L.) N.E.Br. seeds on the native seed bank of dunes

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Plants have developed a number of mechanisms that allow them to assess the best time for germination. Timing of seedling emergence may strongly affect fitness in competitive and invasive environments. We tested the competitive relationships established between the seeds of the invasive species *Carpobrotus edulis* and the native species seeds in coastal dune ecosystems. Because of possible residual effects on the dune soil (Arenosol) produced by the invasion of *C. edulis*, which might affect those relationships, we established two competitive conditions: soil from invaded areas, and soil from areas without invasion. We study germination rate and timing of *Malcomia littorea* (L.) R.Br. and *Scabiosa atropurpurea* L., two native coastal dune species, and of *Carpobrotus edulis*, an invasive species. The experiment was performed at low versus high seed densities and in intra-or interspecific conditions. Substrates were also analyzed in both areas (invaded and native) to test for differences exerted by *C. edulis*. It has been detected a negative effect on seed germination associated with increased density of *C. edulis* and after previous germination of the exotic seeds. The effect of the substrate (invaded or native soil) was smaller. It appears that *C. edulis* modifies the soil environment from an early stage of development, causing a direct negative effect on the germination of native plants.

Keywords: *Carpobrotus edulis*, invasion, seed competition



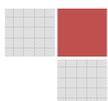
Effects on germination. Testing the effect of the presence of *Carpobrotus edulis*(L.) N.E.Br.in the native sand dunes seed bank.

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Plants have developed a number of mechanisms that allow them to assess the best time for germination. Timing of seedling emergence may strongly affect fitness in competitive and invasive environments. It is becoming more accepted that *Carpobrotus edulis* can change ecosystem function, acting as an “ecosystem engineer”, exerting control over ecosystem processes and creating conditions that favor its own survival at the expense of native plant community. We tested the competitive relationships established between the invasive succulent plant *C. edulis* and the seeds of the native species in coastal dune ecosystems (Northwest of Iberian Peninsula). Because of possible residual effects on soil produced by the invasion of *C. edulis*, which might affect those relationships, we organized an experiment establishing germination conditions in soil from invaded areas and soil from areas without invasion. We examined germination rate and timing of *Malcomia littorea*(L.) R.Br. and *Scabiosa atropurpurea* L. The experiment was performed at low versus high seed densities and in either intra or interspecific conditions. This is an adaptation based on the experimental design of replacement series (de Wit, 1960).The residual effects on the dune soil due to invasion by *C. edulis* were lower as we increase the density of native seeds, so that, density might play an important role in the competitive relationships between *C. edulis* and these native species.The lowest ratio of native seed germination was observed in the presence of *C. edulis*, especially in trials with native soil. This suggests that the competitive success of *C.edulis* could be mainly due to mechanisms such as light competition, allelopathy, etc and not so directly to soil changes resulting from the invasion.

Keywords: *Carpobrotus edulis*, invasion, Native seed bank responses, Replacement series



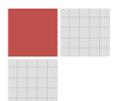
Evaluating the residual effects of *Carpobrotus edulis* (L.) N.E.Br. invasion on native species from the dunes of the southwest coast of Galicia. Implications for restoration.

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It is becoming more accepted that *Carpobrotus edulis*, may actually change ecosystem function. It is acting as an “ecosystem engineer”, exerting control over ecosystem processes and creating conditions that favor its own survival at the expense of native plant community. Our aim is to assess the residual effects on the dune soil (Arenosol) produced by *C. edulis* invasion, and monitor the establishment capacity of native species in those ecosystems in which *C. edulis* has been recently removed. Experimental plots were established in dunes where either native vegetation or *C. edulis* were previously removed. We evaluated the germination, survival, growth and reproduction of *Malcomia littorea* (L.) R.Br. Each plot received three treatments: *M. littorea* seeds, *M. littorea* seedlings, and unplanted. It was monitored every three weeks until senescence. Substrates were also analyzed in both areas (invaded and native) to test for differences exerted previously by *C.edulis*. There were no significant differences in the establishment and germination of the native plants in both areas. This could be because the residual effects on soil are not the most important mechanism in the invasion of *Carpobrotus edulis*. Its competitive success may be due mainly to other mechanisms such as competition for light and nutrients or allelopathy. Therefore, the manual removal of *C. edulis* with subsequent monitoring to help the native vegetation establishment and to avoid new exotics may be the best restoration strategy.

Keywords: *Carpobrotus edulis*, invasion, residual effects, dunes restoration



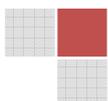
Introduced *Brassica nigra* populations exhibit greater growth and herbivore resistance but less tolerance than native populations in the native range

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Rapid post-introduction evolution has been found in many invasive plant species, and includes changes in defense (resistance and tolerance) and competitive ability traits. Here, we explored post-introduction evolution of a trade-off between resistance to and tolerance of herbivory, which has received little attention. Through a common garden experiment in a native range, nine invasive and sixteen native populations of *B. nigra* were compared for growth and defense traits. Invasive populations had higher resistance but lower tolerance of herbivore damage than native populations. Invasive populations survived better and produced more seeds than native ones when released from herbivores; but fitness was equivalent between the regions under ambient herbivory. The invasive populations grew taller, produced more biomass, and lighter seeds than natives irrespective of insecticide treatment. Besides supporting the idea of post-introduction rapid evolution of plant traits, our results also contribute to an emerging pattern of both increasing resistance and growth in invasive populations, contrary to the predictions of earlier theories of resistance-growth trade-offs.

Key words: *Brassica nigra*, enemy release hypothesis (ERH), EICA, shifting defense hypothesis (SDH), invasive species, glucosinolates, defense, tolerance



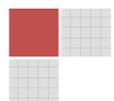
Mechanisms involved in the invasion by Australian *Acacia* species: mutualisms, plant-soil feedbacks and more?

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Australian *Acacia* species have been widely used around the world in forestry and gardening and, as a result, landscapes in many parts of the world are now dominated by planted or invasive stands of acacias. *Acacia* species are involved in many different mutualisms in their native range including belowground interactions with microorganisms such as mycorrhizal fungi and symbiotic nitrogen-fixing bacteria, and aboveground interactions with pollinators and seed dispersers. Nevertheless, the ability to establish mutualism in not native areas and the relevance of those for population growth and invasion is virtually unknown. Therefore, one aim of our research is to assess the diversity, origin and effectiveness of the rhizobia associated with the most invasive *Acacia* species in Portugal (*A. longifolia*, *A. dealbata* and *A. saligna*). Our results show that these acacias are nodulated in the field mainly by Australian bacteria of only one genus (*Bradyrhizobium*) and that this association is effective at promoting plant growth. A belowground invasion of the Australian bacteria that disrupts the native legume-mutualism association has also been seen in coastal dunes invaded by *A. longifolia*. Future research will also include the diversity and function of mycorrhizal fungi associated with Australian species that are invasive in Portugal. A second objective of this project is the study of the reproductive biology and associated mutualisms in invasive populations. Australian acacias are considered partially self-incompatible and dependent on animals for pollination, which are not typical traits of invasive species. Nevertheless, they are known for the huge seed crops produced in invaded areas and their long-lasting seed banks. Investment in reproduction seems to be different in native and invaded areas for some species, but the degree of self-compatibility and the identity of the pollinators and seed dispersers in the invaded area remain to be elucidated. These aspects are currently being studied for *A. longifolia*, *A. dealbata*, *A. melanoxyton* and *A. saligna* in Portugal. Finally, we are also studying two other related processes that might be important in the invasion by Australian acacias: the existence of positive plant-soil feedbacks in the invaded soils, which is related to the ability to establish successful belowground mutualisms, and the existence of genetic and/or phenotypic differences between native and invasive populations that can contribute to their superior performance in the invaded area.

Keywords: dispersers, diversity, mycorrhiza, pollinators, reproductive biology, rhizobia



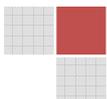
Effect of the exotic *Carpobrotus edulis* (L.) N.E.Br. on cliff plant communities.

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One of the greatest threats to biodiversity is the invasion and establishment of an alien invasive species. The result of a successful plant invasion is a progressive and irreversible homogenization of the ecosystem. It is often characterized by exercising control over ecosystem processes. The long-term effects of invasions on biological diversity are not only the loss of biodiversity, but also permanent changes in ecosystem processes, changing environmental conditions and resource availability. It is necessary to consider that plants selectively affect the soil biota associated with the rhizosphere, either during the decomposition process or by releasing organic compounds, thereby establishing feedback interactions between plants and soil. *Carpobrotus edulis* is a perennial and invasive herbaceous plant that is rapidly occupying coastal environments, often altered or with intense human use. It settles mainly on coastal psammophilous communities and also displaces plant communities on cliffs. The aim of this study was to characterize the invasion process related to the native flora on a cliff with two different levels of invasion. The limiting factors in these areas are the availability of water, the presence of salt and the limited substrate. Plant species are distributed based on the distance to the sea and *C. edulis* density. Our results showed that plant diversity in invaded plots was lower than in plots without *C. edulis*. The exotic plant density is a key factor in native plant distribution.

Keywords: *Carpobrotus edulis*, cliff vegetation, plant invasion, plant diversity



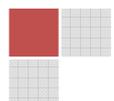
Germination of three native species in soils invaded by *Acacia dealbata* Link

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As an alien plant, *A. dealbata* causes a substantial reduction in the abundance of native species, becoming a serious environmental problem and threatening the indigenous biodiversity. Features that favour the invasive capacity of *A. dealbata* are the ability to reproduce sexually and resprout, to grow rapidly from germination to the reproductive stage and, particularly, its phenotypic plasticity, which allows it to adapt to newly-occupied areas. These characteristics, together with allelopathy, make *A. dealbata* a serious threat to native biodiversity. The aim of this study was to test the allelopathic effect of *A. dealbata* soils on native flora. Different physiological parameters related to germination (total germination, S, AS and CRG indices, starch and protein content and α -amylase activity) and early seedling development (radicle length) of three native species such as *Plantago lanceolata* L., *Taraxacum officinale* (Lam.) Schrank and *Dactylis glomerata* L. cv. Amba were measured. The results showed that protein content was not altered in *A. dealbata* soils, whereas starch content and α -amylase activity showed different patterns, depending on the target species. *P. lanceolata* showed a significantly enhanced α -amylase activity, whereas starch content was consequently reduced, although not significantly, in *A. dealbata* soils. Germination and radicle length showed the same behaviour for all species; while germination was significantly enhanced (+20%) in *A. dealbata* soils, radicle length showed a general decrease (-6%). In all likelihood, these processes do not have equal sensitivity threshold for molecules present in *A. dealbata* soils, so a specific concentration may affect plants in several ways. The viability of seedlings in *A. dealbata* soils is severely affected by radicle inhibition, especially *P. lanceolata* (>50%), which in natural conditions could lead to this native species being at a direct disadvantage to settle in *A. dealbata* stands. This disadvantage could be heightened if the natural conditions controlled in this study (light, moisture, nutrients, temperature) are not favourable.

Keywords: *A. dealbata*, allelopathy, soils, native seeds, germination, radicle inhibition.



Different approaches to *Acacia dealbata* Link control. Effects on soil microbial biology

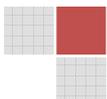
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(1) Departamento de Biología Vexetal e Ciencia do Solo. Facultade de Biología. Universidade de Vigo; (2) Centro de Ecología Funcional, Departamento de Botânica, Universidade de Coimbra. E-mail: souza@uvigo.es

Acacia dealbata tends to invade agricultural areas and native forests that combined with its ability to form dense colonies, make its management a problematic task. Invasion results in a general loss of productivity of agricultural systems with a decrease of biodiversity in natural environments. Different actions, including mechanical, chemical and biological methods have been carrying out to restrain *A. dealbata* invasion. These methods have presented advantages or disadvantages depending on specific conditions. We tested different control methods, combining the invasive plant age (young or mature), control method (cutting, two foliar application of triclopyr -spraying-, cutting plus two foliar application of triclopyr on the sprouts and cutting plus immediate stump application of triclopyr) and herbicide concentration (1% and 48%). Control plots for herbicide application were established inside and outside the invasion area. We checked the effect of the control methods on *A. dealbata* growth (height, diameter and sprouts number) six times during the experiment (from March to November of 2010), and on soil quality parameters (elemental soil analyses, microbial respiration and soil enzymatic activity - acid phosphatase, β -glucosidase, urease, N-acetylglucosaminidase, polyphenol oxidase and glycine aminopeptidase). Herbicide treatments seemed to be highly effective, as mature plants never resprouted and were eliminated together with directly sprayed plants after the first application. The second application eradicated plants from the cut plus foliar herbicide on the sprout treatment. Contrarily to the negative herbicide effects on biological activities expected, we did not find any differences or elevated enzymatic activity and microbial respiration in plots where triclopyr was applied, in comparison with herbicide application outside of the invaded area. There were no differences in these soil parameters contrasting plots with and without herbicide application. These results suggest that the differences are associated with the presence of *A. dealbata*. Cutting plus herbicide application showed generally higher values on enzymatic activity and microbial respiration, even when no significant differences were found. Cutting during the growth period of young individuals seems to exert a stimulus affecting microbial parameters, probably due to the release of molecules in the *A. dealbata* rizosphere.

Herbicide application revealed extraordinary results on young and mature individuals of *A. dealbata* without any signs of expected soil damage.

Keywords: *Acacia dealbata*, control methods, plant invasion, herbicide, enzymatic activity, soil respiration, soil quality.



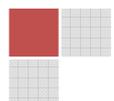
Altered enzymatic activity and microbial respiration in soils invaded by N-fixing *Acacia dealbata* Link

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Alien species drive natural communities to a new status. Plant invasions have demonstrated an ability to modify soil parameters with the subsequent changes on microbial communities. *Acacia dealbata* Link is an invasive species throughout the Iberian Peninsula, and a major problem in this region. Soil enzymes have been suggested as potential indicators of soil quality because of their relationship to soil biology, ease of measurement, and rapid response to changes in soil management. Enzyme activities, as one of the main factors involved in soil reactions, together with soil respiration, are both indicators of soil microbial activity. In this study, carried out in a largely invaded zone in Ribadavia (Galicia, NW Spain), we hypothesized different patterns of microbial behaviour between uninvaded and invaded areas, between different seasons and between areas with different invasion ages. We analyzed elemental soil parameters, microbial respiration and soil enzymatic activities (acid phosphatase (AP), β -glucosidase (BG), urease (U), N-acetylglucosaminidase (NAG), polyphenol oxidase (PPO) and glycine aminopeptidase (GAP)) involved in the N, C and P cycles. Significant differences were found in the soil parameters between invaded and non-invaded areas. *A. dealbata* modifies the soil environment for soil microorganisms and enzyme activity. We detected differences between enzyme activities in the different invaded levels. AP and BG activities were increased in the invaded area. Higher levels in organic matter content, especially cellulose, under *A. dealbata* could explain these high activities. Organic matter content and moisture conditions under the *A. dealbata* canopy could also promote the appearance of fungi, with the consequent NAG-enhanced activity in the invaded zones. PPO and GAP showed irregular behaviour. Enzymatic activity differences depending on invasion age did not show a generalized pattern in the enzymes that were studied, probably due to the short periods between the different invasion ages (8, 12 and 20 years). Despite the fact that values are generally enhanced under *A. dealbata*, microbial respiration did not show significant differences between the invaded and uninvaded zones. Behaviour between zones varies throughout the sampling times; specifically, the oldest invaded zone has seasonal fluctuations in microbial respiration parameters.

Keywords: *Acacia dealbata*, plant invasion, soil quality, enzyme activity, microbial respiration.



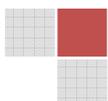
Stakeholders' attitudes and prioritisation of invasive plants in Galicia, Spain

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Human behavior is key to the introduction and spread of invasive alien species. Biological invasions are often the result of production or consumption decisions involving the use of non-native species on agriculture, gardening, forestry, hunting, pet trade, etc. Therefore, the identification of those stakeholders' perceptions and attitudes to invasive species is essential for effective implementation and support of public policies. This article examines the social attitudes to the use and management of invasive plants in Galicia (NW Spain). The perceptions of major stakeholders groups, such as administration, ornamental industry, NGOs, agricultural and forestry trade unions and political parties, were examined using data from a personal interview survey. We used exploded logit analysis to explain the preference ordering of invasive plants based on explanatory variables related to stakeholder type, perceived impacts and plant attributes. There is a greater social awareness and concern for certain species introduced for ornamental and forestry sector (*Acacia spp.*, *Eucalyptus globulus*, *Carpobrotus edulis*, *Cortaderia selloana*). The findings also provide support to the idea of reaching a social consensus in policy making. Stakeholders groups show positive attitudes to different management measures, welcoming in particular education and social awareness strategies, control and eradication measures, and habitat restoration.

Keywords: invasive plants, stakeholder analysis, exploded logit model.



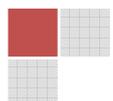
Modelling the patterns and trends of rural landscape invasion by alien plants – examples and future perspectives

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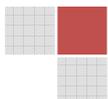
Invasion by alien plants is among the major threats to the ecology and economy of rural landscapes. In fact, invasive plant species can significantly change ecological processes, patterns of native biodiversity and the provision of ecosystem goods and services. In this context, understanding the effects of key drivers of invasion and forecasting future trends in ecosystem and landscape invasion by alien plants are at the forefront of contemporary ecological research and are crucial for the future ecological and economic performance of rural landscapes.

Predictive ecological models can provide valuable contributions to analyse and explain current patterns of invasion as well as to forecast where (and when) future invasions will take place. Using scenarios of future environmental change (from climate to land use) in combination with predictive models can further improve our ability to forecast future invasions and to implement preventive measures accordingly. This presentation will provide some recent examples of application of species distribution models to describe and forecast landscape invasion by individual species, plant functional groups, or large pools of alien plant invaders in rural landscapes of Northern Portugal. These examples will be discussed within the wider context of ecological risk assessment, nature conservation and the sustainability of marginal rural landscapes.

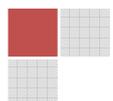


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