ABSTRACTS

"NEOBIOTA 2012"
7th European Conference on Invasive Alien Species

Pontevedra, 12-14 September 2012

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7th European Conference on Biological Invasions

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Halting Biological Invasions in Europe: from Data to Decisions

Abstracts

GEIB Grupo Especialista en Invasiones Biológicas

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INTRODUCTION

The progressing and escalating threats posed by invasive alien species in Europe suggest that immediate cooperative, specific planning is necessary if we are to have any chance to halt biodiversity loss. Scientific, technical, political and legal actions need to be put in place urgently in order to diminish the ecological and economic impacts of biological invasions.

In this framework, NEOBIOTA 2012 provides an international high-level forum to incorporate research into decision making processes and management of invasive alien species. NEOBIOTA constitutes an important opportunity to advance the dialogue and strengthen cooperation between the scientific community, conservation agencies, stakeholders, and policy and decision makers.

Researchers, representatives from governmental entities, non-profit organizations, and any person or party involved in biodiversity conservation and natural resource management are invited to participate and share ideas, new results and opinions in the field of biological invasions.

For more information see http://neobiota2012.blogspot.com.es/

Pontevedra, July 2012

GEIB Grupo Especialista en Invasiones Biológicas

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KEYNOTES

Combining climate-based niche models and simple spread models to estimate economic impacts of invasive species: methods, challenges and prospects

D. KRITICOS

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Policy-makers, biosecurity managers and researchers are becoming more interested in understanding the potential economic costs of invasive organisms, and the likely net benefits of different risk management options. This information can assist decision-making associated with pre-border risk mitigation efforts, as well as post-border responses to the arrival or establishment of unwanted invasive alien species (IAS). Since at least 1985, climate-based niche models have been used to estimate the potential distribution of invasive species in novel regions. From its potential distribution, we can estimate the assets at risk from the IAS. In some cases the ratio of costs to benefits may be obvious, and this information alone may be sufficient to make a biosecurity decision. However, in other cases where the expense may be great, or where a management option involves a long term commitment of resources, decision-makers may be interested in a more detailed, transparent analysis of the economics of the biosecurity risk, and options to manage them. In this paper I describe some recent advances in bioeconomic techniques for pest risk assessment that can inform efforts to prevent the spread of IAS to new regions, or to manage their subsequent spread in the new environment. I will also address frontier issues for the application of these techniques more broadly under current and future climates.

Latitudinal gradient of non-native species richness for marine invertebrates

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Non-native species richness exhibits considerable spatial variation across the globe. In marine ecosystems, most non-native species are known from protected bays and estuaries in temperate latitudes, with relatively few non-native species known from high latitudes. This latitudinal pattern is perhaps best illustrated in the Northeastern Pacific Ocean. Using literature-based occurrence records, non-native species richness (NNSR) varies two orders of magnitude among bays and exhibits an increase from Alaska to California, with decreasing latitude (61^{o} to 32 ^{o}). To control for the effects of habitat, taxonomic group, and search effort in evaluating NNSR across latitude, we conducted standardized surveys of sessile invertebrates in bays spanning this same latitudinal range. Results of these surveys indicate that NNSR exhibits a linear increase (r^2=0.90) from Alaska to California. Surprisingly, native species richness did not exhibit a significant change across this latitudinal range, and NNSR was responsible for an overall increase in total (native and non-native) species richness across latitude.

More broadly, when considering marine invasions from tropical to polar latitudes, the available literature suggests a subtropical peak may exist for NNSR on continental margins that declines toward both the poles and Equator. Such a pattern would be consistent with that described previously for some terrestrial and freshwater taxa, although we caution that analyses and understanding of biogeography for tropical marine biota are extremely limited to date. Several mechanisms may operate alone or in combination to explain the observed latitudinal pattern in marine systems, such as differences in (a) propagule supply, (b) biotic resistance to invasion, (c) environmental resistance to invasion, (d) disturbance regime. At high latitudes for the Northeastern Pacific, it appears that limited propagule may play a role in reduced NNSR, and this appears to be undergoing a rapid change in recent years, due to increased human transfers of marine species. There is also some recent experimental evidence that biotic resistance due to predation is greater in tropical compared to temperate marine systems. However, the relative importance of these various mechanisms has not been evaluated across latitudes. Overall, understanding geographic variation in marine NNSR and invasion mechanisms has received remarkably little attention, despite its critical relevance to evaluating effects on coastal marine ecosystems and advancing management strategies to limit invasion impacts.

Managing invasive trees: changing approaches, priorities and challenges from around the world

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Until fairly recently relatively few tree species featured prominently on lists of the most widespread and damaging invasive species. The picture is changing rapidly. Thousands of tree species have been moved to areas outside their natural ranges where they are used for many purposes. A recent global review listed 357 species of trees that are known to be invasive (i.e. spreading over substantial areas in regions well outside their native ranges) somewhere in the world. Many known invasive species are not yet invasive in some areas, contributing to an "invasion debt". Hundreds of other species are naturalized and many of these will be added to the list of invasive species soon.
Management of invasive trees is becoming increasing challenging because of, among other things: the rapid escalation in the number of invasive trees and the total invaded area, the emergence of new uses and pathways for introduction and dissemination of alien trees, the increasing diversity of types and the overall magnitude of impacts, and the increasing complexity of socio-economic factors that underpin perceptions of the phenomenon and which affect objective cost-benefit assessments and complicate the execution of effective management strategies.
This paper gives: a global snapshot of the current status of alien tree invasions and the problems they cause; reviews some approaches and strategies that have evolved to deal with invasive alien trees in different parts of the world; and offers some ideas on potentially useful strategies for developing more effective and sustainable strategies for management.

ORAL CONTRIBUTIONS

Role of functional diversity and climate change on the invasibility of macroalgae assemblages

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Understanding how climate-driven changes affect the structure and functioning of ecosystems is a central issue in ecological studies. In particular, the response of non-indigenous species (NIS) to those changes is of special concern. In marine systems, NIS are an increasing phenomenon and macroalgae in particular are a significant component of invasions. To improve our knowledge on the role of functional diversity and climate change on the invasibility of marine communities we conducted an experiment in mesocosm using synthetic assemblages of varying functional diversity that resembled macroalgal assemblages from intertidal rock pools characteristic of the western Atlantic coast of the Iberian Peninsula. Specifically, we tested how the increase in temperature and CO_2 partial pressure (pCO_2) interacted with functional diversity of resident macroalgal assemblages and affected the invasion success of the non-indigenous brown macroalga *Sargassum muticum* (Yendo) Fensholt. Early settlement of *S. muticum* germlings was assessed in laboratory using recruitment discs (5.11 cm^2) under control ambient conditions. Survivorship of settled germlings was assessed at different treatment combinations in laboratory while recruitment success was quantified after six months in natural field conditions. Functional diversity was a key driver shaping early settlement of the invader, with significant identity and richness effects. Early survivorship and recruitment results showed evidence of interactive effects of temperature, pCO_2 and functional diversity on the invasion success of *S. muticum*. High temperature enhanced the invasiveness of *S. muticum* but only under current pCO_2 conditions, whereas the identity of functional groups was a key driver of invasibility of assemblages. Present findings highlight the need to consider interactive effects of multiple stressors in ecological studies, particularly when assessing effects of predicted climate change. Despite the limitations of short-term experiments, we believe these experiments are very relevant and can illustrate the direction of the effects and their interactions.

Climate change and marine non-indigenous species: the role of unusual cold events

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New marine invasions have been recorded in increasing numbers along the world's coasts due, in part, to the global warming of the oceans and the ability of many successful invasive marine species to tolerate a broader thermal range than similar native species.
Several marine invertebrate species have invaded the U.S. southern and mid-Atlantic coast from the Caribbean and this poleward range expansion has been coined 'Caribbean Creep'. While models have predicted the continued decline of global biodiversity over the next 100 years due to global climate change, few studies have examined the episodic impacts of prolonged cold events that could impact species range expansions. A pronounced cold spell occurred in January 2010 in the U.S. southern and mid-Atlantic coast and resulted in the mortality of several terrestrial and marine species. To experimentally test whether cold-water temperatures may have caused the disappearance of one species of the 'Caribbean Creep' we exposed the non-native crab *Petrolisthes armatus* to different thermal treatments that mimicked normal and severe winter temperatures. Our findings indicate that *Petrolisthes armatus* cannot tolerate prolonged and extreme cold temperatures (4-6 °C) and suggest that aperiodic cold winters may be a critical "reset" mechanism that will limit the range expansion of other "Caribbean Creep" species. Temperature 'aberrations' such as 'cold snaps' are also an important, and often overlooked, part of global climate change. These climate fluctuations should be accounted for in future studies, particularly with reference to introduced tropical species and attempts to predict both rates of invasion and rates of unidirectional geographic expansion.

Global change, water, and invasion in a semi-arid grassland

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As global changes alter plant communities, one concern is that they may exacerbate plant invasion (Dukes and Mooney 1999, Walther *et al*. 2009). Invasive species could benefit from both change in general and changes that increase resource availability in particular, such as changes in land use, N deposition, and atmospheric CO_2 (Davis *et al*. 2000, Bradley *et al*. 2010). Since 2003, we have been testing the interactive effects of global changes on invasion in semi-arid mixedgrass prairie. We found that while increased snow, summer precipitation, and nitrogen deposition all facilitated invasion, increased snowfall had striking effects, allowing invasion by three species, diffuse knapweed (*Centaurea diffusa*), baby's-breath (*Gypsophila paniculata*), and Dalmatian toadflax (*Linaria dalmatica*), that were rarely observed under ambient conditions (Blumenthal *et al*. 2008). In a second experiment, elevated CO_2 also facilitated toadflax invasion, increasing above-ground biomass, seed production, and new shoot production by more than an order of magnitude, while warming had little effect (Figure 1). In contrast to the dominant perennial grass, western wheatgrass (*Pascopyrum smithii*), which decreased stomatal conductance under elevated CO_2, contributing to an increase in soil water, toadflax increased stomatal conductance, and increased photosynthesis more strongly. Thus, invasive species that grow rapidly and use water liberally may be favored in areas where global change increases water availability. In a third experiment, responses of four native and four invasive forbs to CO_2 and warming depended on life history. The combination of CO_2 and warming favored summer annuals and biennials. While responses of native and introduced species were qualitatively similar within life-history types, the strongest positive responses to future climates were observed for introduced species. Together, these results suggest that global changes that alter water availability will strongly influence invasion in semi-arid regions, posing additional challenges for invasive species management where water availability increases.

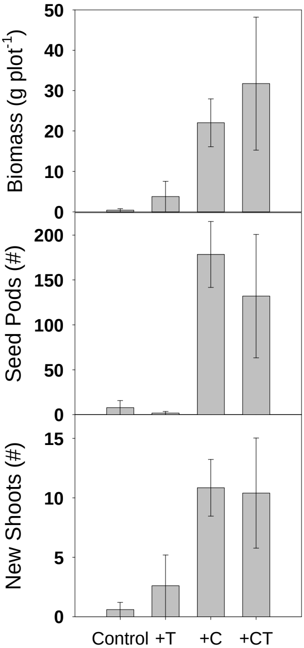

Figure 1. Effects of elevated CO_2 and warming on *L. dalmatica.* Elevated CO_2 (+C, 600 ppmv) increased the total *L. dalmatica* biomass ($F_{1,15}$=22.2, P=0.0003), seed pod production ($F_{1,15}$=34.4, P<0.0001) and new shoot production ($F_{1,15}$=19.5, P=0.0005) in each plot. Warming (+T; 1.5/3°C day/night warming) had no effect on *L. dalmatica* , either alone or in combination with elevated CO_2.

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UV-B radiation and plant invasions - two interacting aspects of global change

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The spread of exotic biota and air pollution have been identified to largely affect ecosystem functioning and human well-being. An area of research, thus far little studied, are intensifying effects between such different aspects of global change (Environmental Effects Assessment Panel 2008). For example, the reduction of the stratospheric ozone layer and the subsequent increase of ultraviolet-B radiation (UV-B) penetrating the biosphere might have unknown impacts on the spread of exotic plant species.
We conducted a series of experiments on mouse-ear hawkweed (*Hieracium pilosella*) and viper's bugloss (*Echium vulgare*). Plants from Europe (native range) and New Zealand (NZ, invasive range) were grown with and without UV-B in two growth chamber experiments (e.g. Beckmann et al. 2012) and under natural UV-B radiation in NZ. We studied responses in growth, leaf characteristics, photosynthetic capacity and the production of secondary metabolites to test the hypothesis that NZ plants are better adapted to UV-B than European plants as a result of directional selection in the new range. Both species displayed high phenotypic plasticity in their functional response to UV-B, e.g. by quickly adapting the efficiency of photosynthesis and producing longer foliar hairs when they were treated with UV-B. While there were significant differences between the two origins (e.g. leaf number, leaf dry matter content (LDMC)), none of them interacted with the UV-B treatment, providing no support for our hypothesis of short-term evolution. However, several typical and strong responses to the UV-B treatments (Newsham & Robinson 2009) were observed in both species, regardless of origin. For example, belowground biomass decreased under UV-B and an increase in the production of phenols, chlorophyll, an increased length or number of leaf hairs could be observed at the same time. Therefore, both species proved to be particularly well predisposed to grow in areas of high UV-B radiation, regardless of their origin.
We conclude that, while we did not find evidence that UV-B radiation triggered short term evolutionary change in the study species in NZ, they do possess specific traits that provide the ability to respond quickly to UV stress, e.g. by increasing hairiness. These traits may be of advantage in the southern hemisphere, especially in interaction with other concomitant stress factors such as summer drought when UV-B levels are highest (Ballizany *et al*. 2012). This hypothesis remains to be tested in these and other plant species.
Furthermore, our findings hint at the necessity to consider UV-B radiation in future research on plant invasions in areas with high UV-B irradiation, such as alpine or polar regions. Species that provide the ability to respond directly to UV-B might have an advantage to invade those areas. Considering the fundamental differences in UV-B exposure between hemispheres and the predicted slow recovery of the ozone layer during this century (e.g. Krzyścin 2012), UV-B intensity will remain high for decades and is interacting with other global change factors. Hence research addressing the effects of UV-B during plant invasions is of increasing importance.

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Invasive alien species assessments for the European Marine Strategy Framework Directive

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The European Marine Strategy Framework Directive (MSFD) aims to achieve Good Environmental Status (GES) in Europe's Seas by 2020. The GES is defined as "the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive". To help Member States interpret what GES means in practice, the Directive sets out eleven qualitative descriptors, which define what the environment will look like when GES has been achieved. The Descriptor 2 (D2) "*Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems*" specifically addresses the problem of biological invasion in marine environment. This is a novel aspect of MSFD, because traditionally the environmental status of marine waters has been evaluated without taking into account the adverse effects of invasive alien species (IAS), i.e. biological pollution. The latter is defined as IAS impacts at a level that disturbs environmental quality by effects on: an individual (contamination by parasites or pathogens), a population (by genetic change), a community (by structural shift), a habitat (by modification of living conditions) or an ecosystem (by alteration of energy flow and organic material cycling). A set of indicators proposed for D2 includes: 1) Number of non-indigenous species (NIS) recorded in an area, 2) Ratio between NIS and native species, 3) Abundance and distribution range of NIS, 4) Impacts of IAS on communities, habitats and ecosystem functioning. The paper presents practical experience gained in initial assessments of marine waters under MSFD using the D2 indicators.

SOM-where over the rainbow: using invasive pest assemblages to rank invasive species

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Predicting future species invasions presents significant challenges to researchers and government agencies. Simply considering the vast number of potential species that could invade an area can be insurmountable. One method, recently suggested, which can analyse large datasets of invasive species simultaneously is that of a self organising map (SOM), a form of artificial neural network, which can rank species by establishment likelihood. This method analyses a region's species assemblage, which highlights species associations (i.e. those species that have invaded the same region), and this information can be used to estimate the likelihood of any one species establishing in a region. The SOM methodology is able to analyse hundreds or even thousands of invasive species at the world level generating establishment likelihoods for all species in all regions of the world. As such, it is possible to simultaneously rank a large number of invasive species by their likelihood to establish in a region. I present results that show this methodology is resilient to significant errors in the raw presence/absence data as well as able to successfully rank those species that can establish in a region above those that cannot. Further, I show how to determine the cut off point between those that can establish and those that cannot and I answer the question of whether the greatest threat to a country is from invasive species already within a country or those not yet established.

Development of molecular surveillance strategies for the monitoring of invasive marine species in Australian ports

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The Australian *National System for the Prevention and Management of Marine Pests* requires tools for the detection and monitoring of invasive marine species from Australia's 18 National Monitoring Network (NMN) ports. Australia's marine pest monitoring manual has surveillance techniques that rely on physical sampling and sorting followed by traditional taxonomic identification. These surveys are labour intensive, require broad technical and taxonomic expertise and are expensive. This has motivated development of molecular diagnostic tools. We have developed a preliminary platform to implement practical, specific, sensitive and rapid molecular diagnosis of invasive marine species from environmental samples. Molecular surveillance, however, requires an understanding of the biology of the target species, extensive laboratory and field validation, optimisation of sampling methods, temporal and spatial variation and laboratory quality assurance to form a viable surveillance framework. We have developed sample handling methods and a brine shrimp internal control to monitor for sample quality, and qPCR assays for the sensitive and specific detection of ten invasive marine species: Asian bag mussel (*Musculista senhousia*), European clam (*Corbula gibba*), North Pacific Seastar (*Asterias amurensis*), green-lipped mussel (*Perna canaliculus*), European green crab (*Carcinus maenas*), Wakame (*Undaria pinnatifida*), vase tunicate (*Ciona intestinalis*), European fanworm (*Sabella spallanzanii*), Pacific oyster (*Crassostrea gigas*), and Black striped mussel (*Mytilopsis sallei*). Preliminary use of the sampling system and invasive marine species qPCR assays will be discussed in the context of ongoing routine surveillance of ports. We have also begun development of ecogenomic methods for the detection of invasive marine species using 454 pyrosequencing. Results of 454-based spiking experiments with known quantities of invasive marine species DNA will be presented and ways in which it can complement our preliminary qPCR system will be discussed.

Evaluating Detection Limits of Next Generation Sequencing for the Surveillance and Monitoring of International Marine Pests

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Marine pest incursions can cause significant and on-going damage to natural ecosystems, aquaculture, fisheries habitat, infrastructure and social amenity (Bott *et al*. 2010). Most surveillance programmes for marine invasive species require considerable taxonomic expertise, are laborious, and often fail to identify species at the larval stage, and therefore, marine pests may go undetected at the initial stages of incursions.
Recent advances in Next Generation Sequencing (NGS) technologies provide unprecedented opportunities for the development of innovative diagnostic tools able to detect multiple species from a variety of life-stages in environmental samples (c.f., DNA metabarcoding; Taberlet et al. 2012), thereby contributing to more robust surveillance programmes.
Our current research is focused on developing a NGS method that will enable simultaneous detection of multiple international marine pests. This approach first requires evaluation of the specificity and sensitivity of the method and comparison with currently used molecular assays, e.g., quantitative PCR (QPCR).
Marine invasive pests span a large range of species belonging to divergent taxonomic phyla and this makes designing universal molecular primers challenging. In this project an initial *in silico* evaluation of the Cytochrome c Oxidase subunit 1 (CO1) and the Small Sub-Unit ribosomal DNA (SSU or 18S rDNA) genes, found that multiple primer sets would be required to obtain species level identification within the CO1 gene. In contrast a single set of primers were designed to target an ~400 bp region of the SSU rDNA, allowing simultaneous PCR amplification of a wide range of marine invasive pests. Artificial contrived communities (10 species from 5 taxonomic groups) were created using varying concentrations of known DNA samples, PCR products, and environmental samples (water and sediment) spiked with one or five 160 hr old *Asterias amurensis* larvae (Figure 1).
The environmental samples were initially analyzed using an *A. amurensis* specific QPCR assay (Bax *et al*. 2006) and positive results were obtained for all spiked samples. The contrived community and spiked environmental samples were then run in multiplex using the Roche 454 GS Junior pyrosequencing system, producing ~10’000 DNA sequences per treatment.
The presence/absence and relative abundance of each species was determined bioinformatically by comparing each sequence to publically available databases. The detection limits afforded by 454 pyrosequencing and its ability to accurately identify a range of marine invasive species from a complex mixture of genomic DNA will be presented.

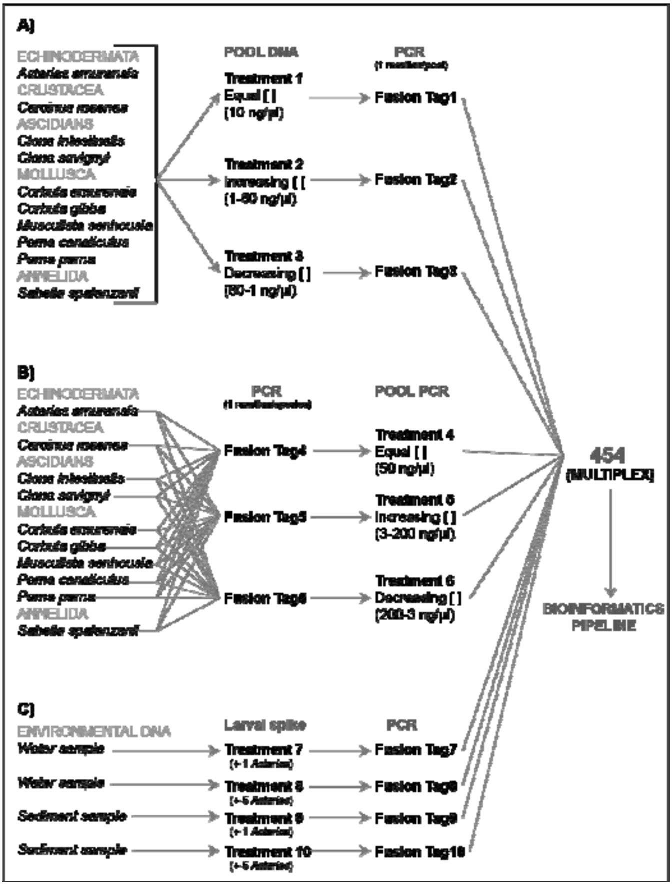

Figure 1. Detailed experimental design showing the 10 distinct treatments used in this study. **A)** DNA samples from 10 international marine invasive species were artificially pooled together at either equal concentration (treatment 1) or at varying concentrations (treatments 2 and 3). Each treatment was then PCR-amplified (SSU rDNA gene) using specifically tagged fusion primers. **B)** Three distinct PCR-amplifications were run for each species individually, using specifically tagged fusion primers. PCR products with identical primer tags were then pooled together at either equal concentration (treatment 4) or at varying concentrations (treatments 5 and 6). **C)** Four environmental samples, including two water and two sediment samples, were collected in New Zealand. Each sample was then artificially spiked with either 1 larva (treatments 7 and 9) or 5 larvae (treatments 8 and 10) of the Northern-Pacific seastar *Asterias amurensis* (not present in New Zealand), and each treatment was then PCR-amplified using specifically tagged fusion primers. All ten treatments were pooled together and analysed in multiplex using the Roche 454 GS Junior high-throughput pyrosequencing system. Approximately 106’000 sequences were obtained (>10’000 per treatment), and a bioinformatics pipeline was used to identify and enumerate the species present.

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Early warning and early intervention's contribution to success in the fight against *Cylindropuntia rosea*, an extremely invasive Mexican cactus in the Valencia region

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Despite being largely ignored by most major invasive plant compediums, the cactus *C. rosea* from central Mexico is considered one of the most invasive of all exotic plants in the Valencia region and clearly the most dangerous to man on account of its vicious spines, capable of inflicting serious injury, including death. Not surprinsingly, in Austrlia the plant has been added to the list of Weeds of National Significance in 2012. Since 1999, the cactus was only known to three locations in the Valencia region, two very large populations with thousands of plants and a very small one. The situation changed radically in 2007, when an early warning system was set up among 270 forest wardens who were trained to recognise the most invasive species. Since then, 45 new populations scattered through the Valencia region were reported (see map). These consisted mostly of less than 500 cacti and grew in some instances in remote, hard to spot places. Early intervention was immediately set in place to prevent this invasive from further spreading. To date, 664 working days have been put into the eradication of 42 of the small and medium-sized newly discovered populations. This means that the extirpation of these small nuclei by hand took up a mean of 15 working days at a total cost of 2.600€. Nowadays, new populations are eliminated as they are discovered. By comparison, eradication of one of the largest populations, consisting of tens of thousands of individuals and covering an abrupt mountainous area of 10ha, with a plant density ranging from 7,5-20tn ha^{-1} will take 4 years and a budget close to 1.000.000€. This population is located in the southern part of the Valencia region and is supposed to have been growing unchecked for over 40 years and to stem from a single introduction. Works are ongoing and will end by 2013. We believe our results are the account of a succesful strategy to completely eradicate an extremely invasive species from a large territory and that they clearly highlight the cost of inaction, thus stressing the need to intervene soon during the invasive process. In addition our results pinpoint to early warning and early intervention systems as the pivotal elements of any serious strategy to tackle the spread of invasive species.

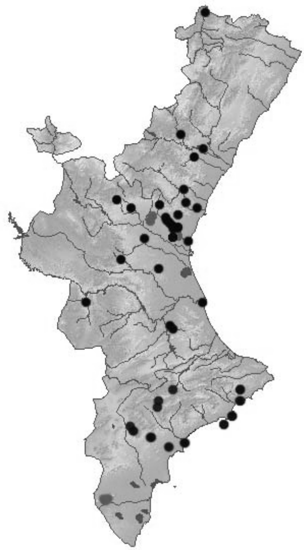

Figure 1. Distribution of *Cylindropuntia rosea* in the Valencia region (East Spain). Black dots represent eradicated populations since 2008 whereas grey dots are populations undergoing eradication or waiting for eradication works to start.

Eradication works of *Cylindropuntia rosea* receive economic support from the European Agricultural Fund for Rural Development (EAFRD) as part of measure 2.2.7 "Conservation and development of Natura-2000 in forest enviroments".

A novel tool for the exploration of alien species information: the European Alien Species Information Network (EASIN)

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To implement the European policies for the efficient prevention, early detection, rapid response, and management of biological invasions and also to evaluate management measures, there is a need for accurate, detailed, and timely information on alien species occurrence and distribution (Simpson *et al*. 2009, Hulme & Weser 2011). The European Commission's Joint Research Center (JRC) has put efforts towards facilitating the exploration of alien species information in Europe by developing the central platform of the European Alien Species Information Network (EASIN; http://easin.jrc.ec.europa.eu/). EASIN aims to facilitate the exploration of existing alien species information from distributed sources through a network of interoperable web services, and to assist the implementation of European policies on biological invasions.To achieve these objectives, EASIN has developed web tools and services that can be utilized freely and independently by any host.Basic functionalities can be accessed using embeddable web widgets having interactive alien species data querying, GIS-based mapping and reporting interfaces.The EASIN web tools and services follow internationally recognized standards and protocols, while ownership of the data remains with its source, which is properly cited and linked.The network allows extraction of alien species information from online information systems for all species included in the EASIN catalogue. This catalogue was based on an inventory of reported alien species in Europe that was produced by reviewing and standardizing information from 43 online databases.Alien species names were extracted for all European countries, i.e. including the 27 EU Member States, the 5 Candidate countries and 17 other European countries. To have full coverage of the four seas surrounding Europe, alien marine species reported from the entire Mediterranean Sea were included, i.e. also from North African and Near East Mediterranean countries.The EASIN catalogue includes information on taxonomy, pathways of introduction (based on the framework proposed by Hulme *et al*. 2008), native range in Europe, and impact. Compilation of the EASIN catalogue is an on-going process and includes several steps to achieve high quality standards. EASIN catalogue entails the basic information needed to efficiently link to existing online databases and retrieve spatial information for alien species distribution in Europe.Using search functionalities powered by the widget framework, it is possible to make a tailored selection of a subgroup of species based on various criteria (e.g., environment, taxonomy, pathways) (see Figure 1). Distribution maps of the selected species can be produced 'on fly' and downloaded by the user.

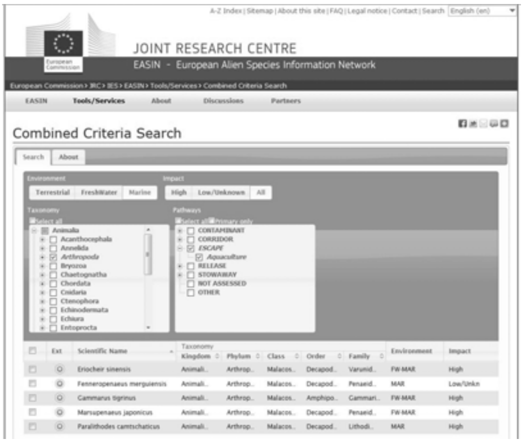

Figure 1. Example of the combined search widget: arthropods introduced in Europe for aquaculture that have escaped and established alien populations in European seas.

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Progress on DAISIE: ALIEN species inventories in Europe updated

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In Europe, a unique alien species inventory with almost 11.000 alien species was established in 2009 through the EU funded Delivering Alien Invasive Species Inventories for Europe (DAISIE) project (http://www.europe-aliens.org). Several high impact publications as well as ground-breaking handbook (DAISIE 2009) documented alarming trends of increasing numbers of newly introduced and naturalized/established species across all groups of organisms. These data enabled to analyse various aspects of invasions at large continental scale, , including their socio-economic aspects, habitat-specific invasion patterns for different taxa, or increasing loss of European taxonomic and phylogenetic uniqueness due to invasions of alien and extinctions of native species. The strength of the European inventory is its completeness in terms of a wide range of organisms covered; however, for obvious reasons such information requires regular updates to reflect the dynamic nature of biological invasions, otherwise it will soon be outdated.
Within last year several updates of the DAISIE database have been made to keep it up-to-date. These have included additional species lists from some understudied regions of Europe where regional lists of aliens started to be developed during the DAISIE project, and new records from other regions. The paper will review most recent patterns of alien species in Europe and will report about the most recent development of the DAISIE database and web portal, including the expert registry. The role of DAISIE in international integration of invasive species information will be discussed.

Estimating true spread progress and handling bias sources in modelling imperfectly observed invasions

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Larger-scale spatio-temporal spread data of biological invasions are frequently based on surveys with imperfect detections: only a portion of the truly extant populations are observed, and often considerable delays compared to the founder events apply. Such inflated data not only hamper scientific analyses of invasions, but can also give rise to misguided management efforts.

Here we show a generally applicable hierarchical Bayesian modelling framework, which not only accounts for imperfect detections, but also estimates the truly realized spread progress explicit over space and time. This framework integrates multiple dispersal processes, local growth and propagule production rates, temporal variation and habitat suitability as invasion drivers, and adds spatially and temporally heterogeneous detection rates to represent the human observation of the invasion. Both processes are jointly fitted and parameters estimated using a Bayesian approach with Markov chain Monte Carlo (MCMC).

We use the framework to investigate the *Ambrosia artemisiifolia* invasion in Austria over more than a century on a lattice comprised of 2,612 cells. According to the latest raw survey data a total of 366 cells (14%) are invaded, while the model concludes that a much higher invasion level of 750 – 1,000 cells, mostly located in the warmer lowland regions, is by far more realistic and many populations remain yet undetected. Depending on survey conditions and efforts yearly detection probabilities of extant populations are very low to moderate (1 – 40%), implying that a considerable time span of years up to decades between founder event and detection may pass by.

For comparisons we also fitted an identical invasion model but assuming perfect, timely detections where the raw spread data would hence directly correspond to the realized invasion progress. We show that the spread kernel parameter and determinants of habitat suitability react very sensitively and can give rise to severe biases: if perfect observation is assumed the dispersal kernel is rather fat-tailed and temperature is much less influential on establishment chances than human land use; once the inflated data nature is accounted for through adding the separate observation process a much narrower kernel emerges and temperature is of at least equal importance as human land use while, concurrently, human presence drives detection chances and hence fosters overrepresentation in botanical records. These findings are not only very well supported by field and experimental evidence, but the full model is overall also much more robust towards minor specification changes. Moreover, its output implies fairly different conclusions in projective applications, particularly with respect to climate change impacts and range expansion velocity. Our analysis concludes that proper integration of features of the survey process is not only feasible and worthwhile, but also comprises an essential step to disentangling drivers of the invasion itself from factors contributing to our view on the invasion and our knowledge of it through observations. This step not only delivers more robust and advanced scientific inferences, but also aids the development of efficient, timely management strategies taking account of information uncertainty, and making the most out of imperfect data in a post-hoc manner.

A multi-forked approach to understand plant invasions: combining historical records, niche-modeling and experimental studies

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Biological invasions still remain an enigma to ecologists and evolutionary biologists. We will present a holistic approach to better understand invasions by combining (i) historical data to reconstruct the spatio-temporal invasion routes, (ii) niche modeling to follow potential changes in niche limits across these invasion routes, and (iii) experimental data on performance of the invader across multiple environments and for populations from both the native and introduced range. We will illustrate this for the European native and highly invasive *Centaurea stoebe* (Asteraceae), which experienced an exceptionally high shift in cytotype frequency and climatic niche during its invasion into North America (Petitpierre *et al*. 2012). Both diploid (EU2x) and tetraploid (EU4x) cytotypes occur in Europe, but only tetraploids have been recorded so far in North America (NA4x) (Mráz *et al.* 2011, 2012). In EU, the 4x cytotype expanded its range from SE towards N and W, mainly facilitated by disturbance, but niche limits of both cytotypes remained fairly stable. In NA, we identified two focal introduction points both around 1890, one in the pacific North West (SW Canada) and one at the Atlantic coast (NY) (Figure 1; Broennimann *et al*., unpublished data). Niche limits changed only little during the invasion in the East, but they largely expanded in the West, being more pronounced in disturbed habitats. In the talk, main emphasis will be given to disentangle pre-adaptation (through differences in traits and plasticity of EU2x vs. EU4x) from post introduction evolution (EU4x vs. NA4x) to explain differences in the spatio-temporal dynamics of the observed range expansions and invasion routes, using our extensive experimental data (Callaway *et al*. 2011, Mráz *et al*. 2011, Hahn *et al*. 2012). We will conclude by outlining the strengths and limitations of this novel multi-forked approach and advocate its broader use for other study systems.

Figure 1. Invasion routes in North America – minimum cost routes are shown with arrows (a). Thick solid lines represent routes occurring in more than 75% of iterations (strong support), thin solid lines between 50 and 75% of iterations (average support) and dashed lines lower than 50% (low support). The date of the first observation by county is shown. Each color corresponds to a time slice of 20 years. Note that for clarity purposes the routes more recent than 1980 are not shown. The distribution of simulated errors in the date of observation is indicated (b) (ex Broennimann et al. unpublished data).

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Plant invasions in Kruger National Park, South Africa: the role of boundaries, general predictors and species-specific factors

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Human land uses surrounding protected areas provide propagules for colonisation of these areas by alien species, and drainage systems of rivers provide pathways for long-distance dispersal of alien species. The influence of protected area boundaries on colonization of protected areas by invasive plants is unknown. We used South Africa's Kruger National Park (KNP) to examine the role of boundaries in preventing colonization of protected areas by alien plants. KNP, in north-eastern South Africa, was founded in 1898 and covers an area of approximately 20,000 km^2. About 350 alien plant species have been recorded in the park (Spear *et al*. 2011).

We drew on a spatially explicit data set of more than 27,000 alien plant presence records and >2 million absence records collected between 2004 and 2007 and which covers the entire park. We worked along the western and southern park boundaries, delineating 638 contiguous, 1 km wide segments that extended 1500 m into the park.

First we developed a general model for predicting drivers for all alien plants using binary classification trees. We then explored the similarity between determinants of invasions identified by the general model and those identified by species-specific models, using classification trees and random forests.

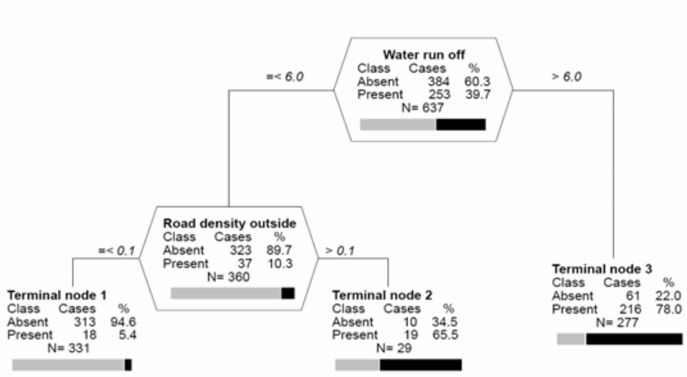
The number of records of invasive alien plants declined rapidly beyond 1500 m inside the park; thus, we believe that the park boundary effectively limits the spread of non-native plants (Foxcroft *et al*. 2011). In the general species model the number of invasive alien plants inside the park was a function of the amount of water runoff, density of major roads, and the presence of natural vegetation outside the park (Figure 1a). Of the types of human-induced disturbance, only the density of major roads outside the protected area significantly increased the number of alien plant records (Foxcroft *et al*. 2011).

For the species specific model we used the six most prevalent plant species, namely *Ageratum houstonianum*, *Chromolaena odorata*, *Xanthium strumarium*, *Argemone ochroleuca*, *Opuntia stricta* and *Lantana camara*. The general model established by using a multi-species data set worked well (equal to 92.9% from the full species dataset), for predicting the occurrence of the individual species analysed (Table 1b).

The species-specific model showed that the occurrence can also be reliably predicted based on landscape characteristics identified by the general multi-species model, namely water runoff from surrounding watersheds and road density in a 10 km radius (Table 1b; Jarošík *et al*. 2011). The presence of main rivers and species-specific combinations of vegetation types are reliable predictors from inside the park.

The predictors from the outside and inside of the park are complementary, and are approximately equally reliable for explaining the presence/absence of current invaders (Jarošík *et al*. 2011). Predictors from outside KNP (e.g. density of major roads) and inside the KNP (e.g. vegetation types) can be used reliably to identify high-risk areas to improve the cost effectiveness of management, to locate invasive plants and target them for eradication.

a



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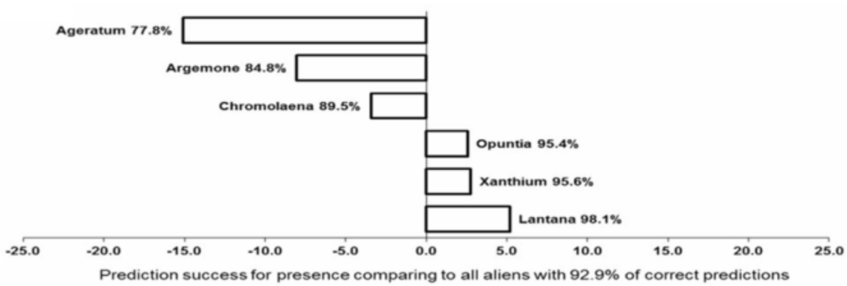

Figure 1. Similarity between the optimal general model based on all species (Foxcroft *et al.* 2011), and the prediction success for presences (%) of the species-specific models (Jarošík *et al.* 2011). **a** Classification tree analysis of the binary probability of the alien species presence in Kruger National Park. Probability of presence was determined on the basis of water runoff in the park and road density adjacent to the park **b** Each species was evaluated by dropping the data separately for each of the six species from the general optimal tree. Prediction success for all species presences, describing percentage of successful predictions, was 92.9% (vertical line at zero point of x-axis).

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Priority setting for invasive species management: integrated risk assessment of multiple Ponto Caspian invasive species into Great Britain

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Invasive species drive important ecological and economic losses across wide geographies, with some regions supporting especially large numbers of non-native species and consequently suffering relatively high impacts. For this reason, integrated risk assessments able to screen a suite of multiple invaders over large geographic areas are needed for prioritizing management and control options.
In Europe, more than 40 Ponto Caspian species are known to have invaded in the last decades, with important ecological and economic impacts. A total of 16 Ponto Caspian aquatic species (ten gammarids, one isopod, two mysids and three fishes) have been short-listed as potential future invaders of British waters, whose introduction and spread is vital to prevent.
The main objectives of this study are: i) to use species distribution models based on climatic conditions to model the potential distribution of 16 Ponto Caspian species in Great Britain, ii) to combine the individual distribution models to produce a 'Heat Map' of Great Britain that allows identifying the most vulnerable regions to multiple invasions, and iii) to narrow down the areas at a higher risk in Great Britain based on observed differences in water chemistry between invaded and un-invaded water-bodies in Europe.
Climate suitability maps for 16 species in Great Britain differed depending on the eastern/western distribution of species in Europe, which was related to their respective migration corridor: southern (Danube-Rhine rivers), and central (Don, Dnieper and Volga rivers and Baltic lakes). Species migrating through the southern corridor whose suitability was high across large parts of Great Britain included three gammarids (*Corophium curvispinum, Dikerogammarus bispinosus* and *D. villosus*) and two mysids (*Hemimysis anomala* and *Limnomysis benedeni*).
These species are currently located along the Danube-Rhine corridor, they are widely present in The Netherlands and Belgium, and patchily also in France, which may explain their high suitability in Great Britain. Three of these species, *C. curvispinum, D. villosus* and *H. anomala*, are already present within their respective high climatic risk areas in Great Britain, which reinforces the results of the models.
A climatic 'Heat Map' combining the results of all 16 species together pointed to the SE of England as the area most vulnerable to multiple invasions, particularly the Thames, Anglian, Severn and Humber river basin districts (Figure 1A).
The response of species' presence/absence to water chemistry factors, modelled through Generalized Additive Models (GAM) was similar: the probability of presence increased with alkalinity, decreased with pH, showed a unimodal response to nitrate peaking at 10 mg/L approximately, and decreased with sulphate and DOC. GAM further suggested that alkalinity concentration > 120 mg/L in SE England may favour the establishment of Ponto-Caspian invaders (Figure 1B).
The Heat and alkalinity maps presented here provide means for the scientifically-informed prioritisation of resources towards particular species and geographic regions. Such tools have great utility in helping environmental managers focus efforts on the most effective prevention, management and monitoring programmes.

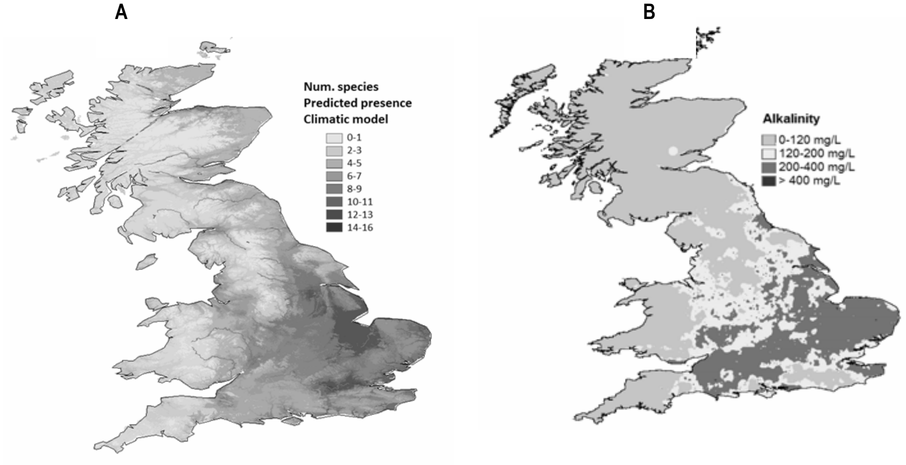

Figure 1. A. 'Heat Map' of Ponto Caspian species in Great Britain based on species distribution models (Maxent algorithm). The map represents the probability of presence of 16 Ponto Caspian species based on the match between the climatic conditions in Great Britain and those of the European range of species. Blue lines represent major British river courses. B. Alkalinity map of Great Britain. Waterbodies with alkalinity < 120 mg/L (in green) are less likely to be invaded by Ponto Caspian species.

Stochastic models for introduced species and their interactions with native species

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Initial populations of introduced species are typically small, and their fates depend on stochastic birth and death events. Accounting for this stochasticity, we develop and analyze mathematical models for the population dynamics and genetics of two competing species: an introduced species and an ecologically similar native competitor. Under the assumption of repeated and ongoing introduction events, the introduced species can eventually establish and finally exclude the native competitor from the community. We compute the expected times until these events happen and study their dependence on parameters of the interspecific interaction and the introduction process. The intensity of competition between introduced and native species has opposing effects at different stages of the invasion process (Figure 1). The stronger the competition between the two species is, the longer it takes for the introduced species to establish, whereas the expected time until one of a pair of coexisting species is excluded from the community decreases with competition intensity. A striking consequence is that the expected time to the extinction of the native species is lowest for an intermediate intensity of competition. Two important parameters of the introduction process are the rate at which introduction events occur (propagule frequency) and the number of individuals introduced in any single event (propagule size). These parameters are often combined into a single measure, propagule pressure, which is considered one of the most important predictors of invasion success (Lockwood *et al*. 2005). However, it is unclear whether we should combine them by taking the product of propagule size and frequency or whether we should account for the temporal distribution of introduced individuals. Our model shows that under favorable environmental conditions the temporal distribution is of little relevance. In contrast, under adverse conditions a high propagule size is more important than a high propagule frequency for the introduced species to proceed to the next invasion stage. Yet, these ecological phenomena might not suffice to predict the success of an introduced species and its consequences for a native competitor. A reduction in native species population size causes a corresponding reduction in genetic diversity and thus may render adaptation to a changing environment more difficult. This leads to a synergistic feedback between ecological and genetic effects of introduced species on their native competitors, with the potential of accelerating their extinction.

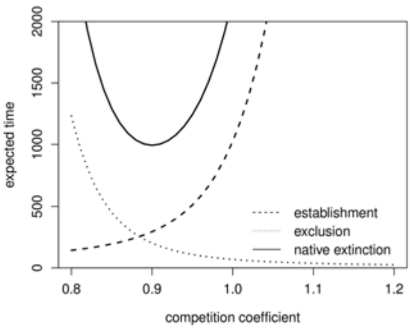

Figure 1. The antagonistic effects of competition strength on the establishment time of the introduced species (dashed line) and the expected time to the exclusion of one of two coexisting competitors (dotted line) lead to a minimum in the total time to native species extinction (solid line).

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Weed risk assessment: do data help make better decisions?

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Alien weeds pose significant environmental and/or economic costs and methods to assess the potential risk of species introductions are key components in the management of plant invasions. Three broad approaches have been adopted in weed risk assessment: quantitative statistical models, semi-quantitative scoring, and qualitative expert assessment. Yet, the effectiveness of these different approaches is rarely evaluated. By bringing together perspectives drawn from statistics, complexity theory, bioeconomics and cognitive psychology, this paper undertakes an interdisciplinary appraisal of weed risk assessment. Problems in obtaining an objective measure of the hazards posed by weeds, challenges of predicting complex hierarchical and nonlinear systems, difficulties in quantifying uncertainty and variability, as well as cognitive biases in expert judgement, all limit the utility of current risk assessment approaches. The accuracy of weed risk assessment protocols is usually insufficient given inherent low base-rates even when the costs and benefits of decisions are taken into account, and implies that the predictive the value of weed risk assessment is questionable. Current practices could be improved to address consistent hazard identification, encompass a hierarchy of spatio-temporal scales, incorporate uncertainty, account for failures to generate realistic base-rates, and train risk assessors to limit cognitive biases. However, such refinements may still fail to predict weed risks any better than a simple knowledge of prior invasion history and quality of climate-match. Alternative approaches include scenario planning that seeks qualitative inputs regarding hypothetical events to facilitate long-range planning using multiple alternatives each explicit in their treatment of uncertainty. This represents a change from prevention towards adaptive management where the difficulty in prediction is acknowledged and investment targets early detection, mitigation and management.

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A new method to assess the present and actual environmental impacts of alien plants and plant pests in pest risk analysis

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Assessing the environmental impact of alien plants and plant pests is notoriously difficult, in particular in pest risk analyses (PRA) where experts are usually asked to assess both the current impact in the area of present occurrence and the potential impact in the PRA area, based on limited information. In general, there is little guidance on how to score the environmental impact, leading to low consistency in the assessment. In contrast to the economic impact for which standard assessment methods exist and are used, there is no standard and easily applicable method for assessing the current and potential environmental impacts of a plant pest. Weed risk assessments schemes already exist and are applied worldwide, with some success, but these usually assess invasiveness rather than environmental impact.

New protocols have been developed in the framework of the EC 7th Framework Programme project PRATIQUE to provide guidance on environmental impact assessment in the EPPO pest risk analysis decision-support scheme and enhance consistency between risk assessors and risk ratings for different pests. A set of questions with rating guidance and examples are provided, and individual scores are summarized into final scores, using a hierarchy of risk matrices, to assess current and potential environmental impacts. Two separate protocols are available for alien plants and plant pests. The two schemes presented here have already been validated in the framework of PRA panels and other working groups, using various cases of well-studied alien plant pests and plants. These validation tests showed that the schemes provide assessments that match experts' opinions but, above all, significantly increased consistency among experts' judgements. These protocols could also be used to assess environmental impact in other PRA schemes as well as to assign alien species to regional black lists or to prioritize species for management decisions.

. A new generation risk assessments of alien species - Risk assessment of all known alien species in Norway, using a new quantitative methodology suitable for all taxonomic groups and habitats

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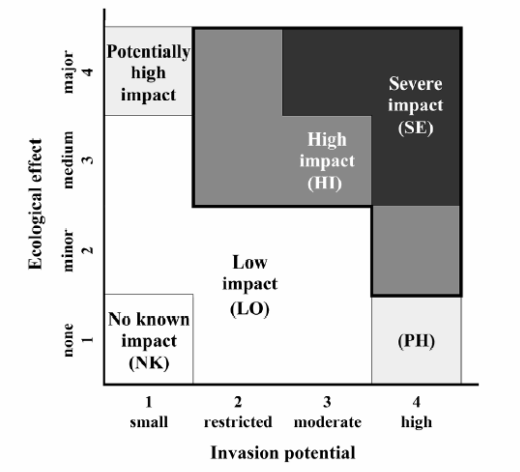

In June 2012 a report called “Alien species in Norway – including the Norwegian Black List 2012” was published. The report includes a new generation of ecological risk assessmens of the 1180 known alien species which are reproducing in Norway. In total, there are 2320 known alien species in Norway but 1140 of these alien species are not reproducing - or is considered not to have the opportunity to reproduce in Norway within 50 years.

The risk assessments are done using a newly developed method, which is based on quantitative rather than qualitative criteria. The method estimates the species’ probability to establish and disperse (that is, the invasion potential of the species) and its effect on the indigenous species and nature. The set of criteria may be used on all species groups and is independent of geographical region. The set of criteria consists of 9 criteria, where 3 determine the invasion potential and 6 determine the ecological effect. All criteria are used for all species, and from this, the species are placed in one out of five categories: severe impact (SE), high impact (HI), potentially high impact (PH), low impact (LO) or no known impact (NK). The two categories which indicate highest risk – SE and HI – constitute the 2012 Norwegian Black List.

A selected number of potential door-knockers are also risk-assessed using the same method.

There is a strong need for an international set of criteria for risk-assessment of alien species, and The Norwegian Biodiversity Information Centre hopes that the method developed here may be of assistance in this regard. In addition there is a need for more focus on lack of knowledge regarding alien species in Norway.

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A conceptual framework for prioritization of invasive alien species for management

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The number of invasive alien species is increasing and so are the impacts these species cause to the environment and economies. Nevertheless, resources for management are limited, which makes prioritization unavoidable. We present a prioritization framework which can be useful for decision-makers as it includes both a scientific impact assessment and the evaluation of impact importance by affected stakeholders. The framework is divided in five steps, namely 1) stakeholder selection and weighting of stakeholder importance by the decision-maker, 2) factual description and scoring of changes by scientists, 3) evaluation of the importance of impact categories by stakeholders, 4) calculation of weighted impact categories and 5) calculation of final impact score and decision-making. The framework could be used at different scales and by different authorities. Furthermore, it would make the decision-making process transparent and retraceable for all stakeholders and the general public.

TEASIng apart alien-species risk assessments: an analysis for best practices

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Some alien species cause substantial impacts, yet most are innocuous. Given limited resources, forecasting risks from alien species will help prioritise management. Given that risk-assessment (RA) approaches vary widely, a synthesis is timely to highlight best practices. We reviewed quantitative and scoring RAs, integrating > 300 publications into arguably the most rigorous quantitative RA framework currently existing, and mapping each study onto our framework, which combines Transport, Establishment, Abundance, Spread
and Impact (TEASI). Quantitative models generally measured single risk components (78% of studies), often focusing on Establishment alone (79%) (Fig. 1b). Although dominant in academia, quantitative RAs are underused in policy, and should be made more accessible. Accommodating heterogeneous limited data, combining across risk components, and developing generalised RAs across species, space and time without requiring new models for each species may increase attractiveness for policy applications. Comparatively, scoring approaches covered more risk components (50% examined > 3 components), with Impact being the most common component (87%), and have been widely applied in policy (> 57%), but primarily employed expert opinion (Fig. 1a).

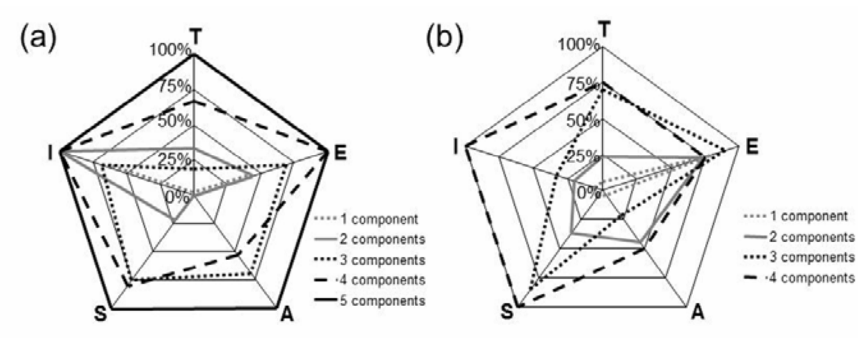

Figure 1. Percent of qualitative/semi-quantitative (scoring) risk assessments (a) and quantitative risk assessments (b) considering the different stages of the invasion process, split into models containing different numbers of TEASI components (Transport, Establishment, Abundance, Spread, Impact).

Our risk framework provides guidance for questions asked, combining scores and other improvements. It illustrates that the qualitative/semi-quantitative scoring methods are special cases of quantitative models by mapping each question to a component in the quantitative TEASI risk model.

Thus, this framework provides the skeleton structure and serves as a starting point for future advances in risk modeling. Importantly, our aim in promoting such an integrative approach was not to suggest that all elements need to be estimated to yield a useful risk assessment, but rather to identify opportunities for improvement.

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Novel ecological strategies determines the impact on community production by two successful non-native seaweeds

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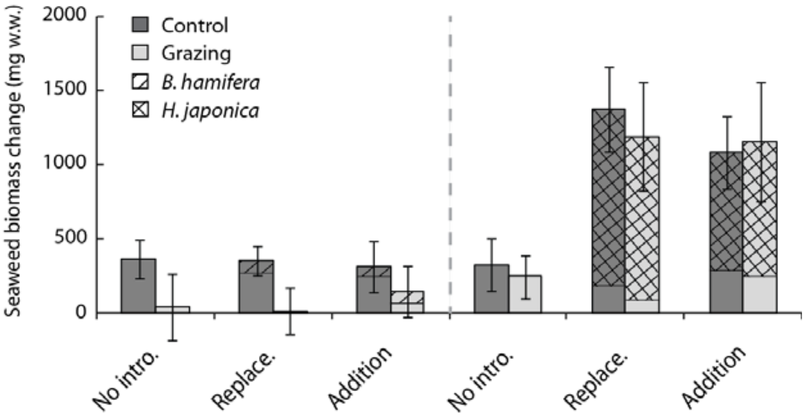
Invasive plants regularly increase plant community production in the recipient environment which may lead to a number of effects at ecosystem level, such as a higher plant litter decomposition rate, increased soil microbial biomass and more rapid cycling of macronutrients (Liao *et al*. 2008; Vilà *et al*. 2011). However, little is known of how invasion affects primary production in benthic seaweed communities, an important marine counterpart to terrestrial plant communities.

We studied the effect on seaweed community production by two successful non-native seaweeds; *Bonnomaisonia hamifera* and *Heterosiphonia japonica* in an outdoor microcosm experiment. The non-native seaweeds were cultivated for three weeks in single and mix cultures together with four naturally co-occurring native species from the red algae community of the Swedish Skagerrak coast. We examined the effects of invasion including three levels; no introduction (3 species), introduction through replacement of a native alga (3 species) and introduction through addition to the native species pool (4 species). The grazing isopod *Idotea granulosa* was applied in natural densities to half of the replicates.

Species mixtures containing *H. japonica* had over four times higher biomass production compared with un-invaded mixtures both when *H. japonica* replaced a native alga and when it added to the number of algal species. On the contrary, invasion by *B. hamifera* did not affect the biomass yield significantly. The difference in impact between the two invaders may be connected to that they are successful for separate reasons. The large biomass production in the communities invaded by *H. japonica* could be explained by the rapid growth rate of the invader. *B. hamifera* on the other hand, did not grow faster than the native seaweeds, but is known to produce an efficient grazer deterrent chemical (Enge *et al*. in press 2012). A follow-up experiment showed that isopods with no choice but to feed on *B. hamifera* had a significantly reduced survival compared to if they got to feed on the other experimental algae.

This study shows that introduced species belonging to the same functional group may successfully invade the same habitat and yet have distinctly different impacts on community productivity in the recipient. This has a negative implication for the predictability of impacts by species invasions. However, if traits connected to the ecological strategy of the invaders are known, potential impacts will most likely be predicted with a higher accuracy.

Mean biomass change of seaweeds grown for three weeks in two sub-sets of mixcultures; with introduction of *B. hamifera* on the left hand side and *H. japonica* on the right hand side ($\pm CI_{95}$, n = 10-12). Treatments were: no introduction, introduction through replacement of a native alga and introduction through addition to the native species pool. Half of the replicates were grazed by the isopod *Idotea granulosa.*



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Behaviorally-mediated interactions between native and invasive ecosystem engineers influence community structure

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Habitat-forming invasive species cause large, novel changes to the abiotic environment. These changes may elicit important behavioral responses in native fauna, yet surprisingly little is known about mechanisms driving this behavior, let alone how such trait-mediated responses influence the fitness of native species and their communities. We identified low dissolved oxygen as a key abiotic change created by the habitat-forming invasive seaweed, *Caulerpa taxifolia*, which influences an important behavioral response (burial depth) in the native infaunal bivalve *Anadara trapezia*. In *Caulerpa*-colonized areas *Anadara* often emerged completely from the sediment and we experimentally demonstrate that hypoxia beneath the *Caulerpa* canopy is the mechanism instigating this "pop-up" behavior, presumably as the clam attempts to protrude into better oxygenated water above the benthic boundary layer.

From a community perspective, the pop-up behavior facilitated a novel and greatly enriched epibiont community. Anadara extended >30% of their shell surface above the sediment when responding to *Caulerpa*. The exposure of this shell above ground provides rare, hard substrata for colonization. Consequently, clams in *Caulerpa* had a significantly higher diversity and abundance of epibiota compared to clams in uninvaded sediments. We experimentally isolated the role of clam burial depth from direct habitat influences or differential predation in driving this pattern. Burial depth was the one factor that overwhelmingly influenced epibiont species richness and abundance. That *Caulerpa* controls epibiont communities by altering *Anadara* burial depths implies that even subtle responses of one ecosystem engineer to another can drive extensive community-wide effects.

Impact of a plant invader on its neighbours: size matters at home but not away

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Impact of exotic plant invaders can be driven by either resource competition linked to biomass and density, or by interference competition associated with a per capita effect, such as through allelopathy (Parker *et al*. 1999, Simberloff 1985, Weidenhamer *et al*. 1989). We aimed at disentangling these two types of impact in *Centaurea stoebe*, native to Europe and highly invasive in North America by growing it in pairs with either 15 European (old) or 15 North American (new) neighbours. Old neighbours grew larger and could use available soil water more efficiently for growth compared to their new neighbours suggesting limited plasticity of new neighbours to use additional water. *Centaurea stoebe* suppressed the relative growth rate of its neighbours from both ranges. Interestingly, in the presence of competition, biomass of *C. stoebe* explained a significant and substantial amount of the variation in biomass of the co-evolved neighbours, but only a minor amount of the variation in biomass of the new "naïve" neighbours. This indicates that the impact of *C. stoebe* is driven by biomass in its native range but by interference in the introduced range. Moreover, the relative efficiency index as an indicator of mixture dynamics suggests that European plants are more successful in competing with *C. stoebe* than North American plants. Our results suggest that in the native range C*. stoebe* and its neighbour species are suppressed by each other, and that the reciprocal impact is biomass-related. In contrast, *C. stoebe* impacts neighbours in North America by a mechanism that is not or only loosely related to its biomass, and that North American plants do hardly impose any competitive impact on *C. stoebe*. Thus, control management reducing the density of *C. stoebe* in the introduced range may not result in a proportional recovery of the native vegetation, as it is expected to happen in the native range.

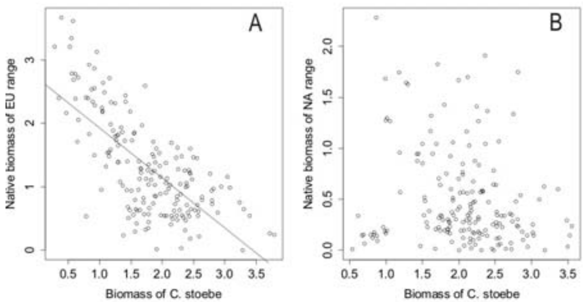

Figure 1. Relationship between the biomass (g) of *C. stoebe* and that of European (A) and North American (B) neighbours in competition condition.

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Harmonia axyridis implicated in native European ladybird declines

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Rates of global extinction are accelerating and show no sign of slowing (Millenium Ecosystem Assessment 2005). Invasive alien species (IAS) are recognised as major drivers of biodiversity loss (Winter *et al.* 2009). IAS afford a unique opportunity to accurately assess threats to biodiversity because the time at which an IAS arrives within an ecosystem is often known, unlike other drivers of change. However, few causal relationships between IAS and species declines have been documented. We used data collated through extensive citizen-driven field surveys in Belgium and Britain spanning decades, as well as intensive monitoring by scientists in Belgium, Britain and Switzerland. The fine-scale data collection, replicated in time (over decades and including detailed observations before and after the arrival of an IAS) and with extensive coverage in three European countries, combined with powerful modern mixed-modelling (statistical) techniques, provided a uniquely rigorous test of the impacts of an IAS on biodiversity. We report rapid, dramatic and ongoing declines in the distribution of formerly common and widespread native ladybirds in Belgium and Britain following the arrival of *Harmonia axyridis*, a globally rapidly expanding IAS (Roy *et al*. 2012). For example, the two-spot ladybird, *Adalia bipunctata*, declined in both Belgium and Britain over five years after the arrival of *H. axyridis*. Trends in ladybird abundance revealed similar patterns of declines across three countries. These analyses implicate *H. axyridis* in the displacement of native ladybirds, particularly those with a high niche (habitat and diet) overlap. There is considerable debate over the relationship between species diversity and ecosystem processes (Rey Benayas *et al.* 2009). Studies indicate that species diversity enhances productivity and stability in some ecosystems, but not in others. However, it is difficult to predict which species are critical to ecosystem function and rapid biotic homogenisation at the continental scale could diminish the resilience of ecosystems and the services they deliver.
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Regime shifts following alien plant invasions

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Large impacts of biological plant invasions on native ecosystems typically occur in cases where invasions lead to fundamental changes in the structure and function of an ecosystem. Such large, persistent changes in ecosystem structure and function are often indicative of a more general phenomenon known as "regime shifts". A regime shift is associated with a change in the dominant system feedbacks and entails the shift of the system from one domain of attraction to another. The presence of internal system feedbacks explains why regime shifts are hysteretic ("sticky"): once the system is in a particular regime, it tends to remain there even if the exogenous drivers that caused the shift are reduced or removed.

Although the drivers and impacts of biological invasions have been extensively studied, the dynamics of invasions have seldom been explicitly analysed in the context of regime shifts. In practice, determining whether an observed ecosystem change indeed represents a regime shift is often difficult. Once the occurrence of a significant change has been recognized, the cause of this change and the feedback mechanisms underlying the shift must be established to ascertain a regime shift.

We explored the insights that may be gained from applying a regime-shift framework to biological plant invasions. To identify alien plant invaders that can bring about ecological regime shifts we selected a wide set of plant invaders which are known to have significant effects on the structure and function of native ecosystems. For each of these species, we synthesized the different feedback mechanisms that maintain invasions of these species, based on the literature.

Applying the regime shift concept to biological invasions has potential for guiding management and restoration of invaded ecosystems. Defining whether a given change is a regime shift is important for determining whether an active intervention may be required, feasible or desirable and, if so, how the restoration should be approached.

Mutualistic networks in the Galapagos Islands. Impacts of invasive species on their structure

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The Galapagos Islands are well known for their valuable natural heritage and for the model ecotourism developed in them. Nevertheless, despite currently having a rather complete knowledge on their biota, there is still a large gap of information on how it functions, as well as on the ecological ‘architecture’ of these peculiar island ecosystems. Thus, for instance, limited information exists regarding two important ecological processes that can modulate the structure and functioning of biodiversity: (1) pollination and (2) seed dispersal. In this talk, I am going to present you the results of an ongoing research project that deepens into such ecological interactions. The aim of the project is to describe the pollination and seed dispersal networks in different islands of the archipelago and to investigate on the mechanisms underlying such network topology. We have compared different habitats and examined the influence of the introduction of alien plants on the structure of pollination and seed dispersal networks. Oceanic islands are known to be highly vulnerable ecosystems to different drivers of global change, including biological invasions. The study of mutualistic networks contributes to better understand how these new species are being integrated into the native communities at the same time that allows making predictions on the risk of extinctions of both native species and ecological/evolutionary interactions in this no-longer pristine archipelago.

Relating invasion impacts to conservation values: a missing link in assessing and managing biological invasions

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Biological invasions can affect biodiversity patterns at all scales, from the gene to the ecosystem level (Vilà *et al*. 2011). Yet there is an ongoing controversial debate on the question whether control and other regulations of non-native species are appropriate or biased by prejudices on introduced species (Davis *et al*. 2012, Simberloff *et al*. 2012). We hypothesise that relating invasion impacts to conservation values is a missing link in many assessment approaches. This evokes repeatedly unnecessary debates and hampers the acceptance of scientifically based impact assessments as well as the prioritisation and implementation of adequate control.
To illustrate that incorporating the conservation value leads to varying assessment results, we analyzed a large regional database on (a) habitats that are affected by highly invasive species and (b) effects of these species on local biodiversity patterns. We argue that the assessment of invasion impacts should be backed by a precise definition of damage (Bartz *et al*. 2010) and related to the conservation value of affected species, communities or habitats. This helps to set priorities and to enhance acceptance of management measures. Moreover, involving other parameters such as feasibility and anticipated success of control in assessment approaches may contribute to improve the management of biological invasions.

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One scoring system for the environmental and economic impact of all alien and invasive animal species

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After an in-depth analysis of environmental and economic impact of alien and invasive mammals in Europe, a classification of impact types and a generic scoring system was proposed (Nentwig *et al*. 2010). In a second step, birds alien to Europe were investigated and the classification system was partially extended (Kumschick & Nentwig 2010). Here we present our recent addition of fish and arthropod species, alien and invasive in Europe, and of their known impact. The classification system for environmental and economic impacts proved to be rather stable after the inclusion of these two very important groups and only minor additions were needed to be applicable to all species. This indicates that our system probably comprises all possible impact categories. A comparison of major alien taxa, for example, allows identifying different impact types which different taxa exert. With the here presented scoring system we offer a prioritization and decision tool to practitioners, uniquely applicable to all alien animals, and easy to use.

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11 years of management of the zebra mussel invasion in the Ebro basin (Northern Spain)

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After 11 years of management of the zebra mussel invasion in the Ebro basin, the Ebro Hydrographic Confederation, the organism which protects and administrates the hydraulic public property, is developing a balance of actions and of the state of invasion with the purpose of evaluating the effectiveness of measures and efforts carried out during this period.
Since the first moment, the main lines of work have been based on prevention, control and eradication measures, unified in the “National Strategy for the Control of Zebra Mussel in Spain” and locally, in the “Emergency Plan 2007-2010”. A wide campaign of larvae analysis and adult control of the species through all navigable water bodies in the Ebro basin (5919 larvae analysis in the period 2004-2011) and an intensive campaign of public awareness directed to interested sectors (navigators, fishermen, environment agents, workers of affected facilities,…) are the main measures carried out as part of the prevention. In terms of control, significant changes in navigation rules have been carried out as well as the control of accesses to the affected reservoirs and the building of disinfection stations near these reservoirs. These measures have slowed down the spread of the invasion in the Ebro basin. Finally, research studies have been developed about methodologies address to the eradication of the problem and technical advice has been given on hydraulic infrastructures in the farming, energetic, industrial sectors and in supplies to populations with the aim of minimizing the impacts of the invasion on the productive systems of these sectors and the ecological impact of the applied treatments in the receiving aquatic medium.
At present, only seven rivers are affected by the invasion of zebra mussel in the Ebro basin, so it can be said that the spread of the pest has had a smaller exponential progression than in other countries. However, the economic impact associated with it is alarming, with an outlay of 13,634,756 € in the 2001-2009 period. At a national level, four hydrographic basins (Cantábrico, Ebro, Júcar and Guadalquivir) contain this alien species in their territory.
As a result of the experience collected in these years, a lack of coordination between the different authorities involved in the management of biological invasions can still be seen, and which makes difficult an effective management. Pest control and eradication are important but expensive, so efforts must be directed towards prevention, which is easier and less expensive. In relation to prevention, awareness campaigns must be aimed at sectors which can take action as spread vectors, as well as the general public, in general, as from all points of view, it is a problem which affects everybody and as a consequence, we must all work to fight against it. Finally, it is interesting to promote relations between the management and research organisms with the purpose of finding a viable solution that brings together several interests and sometimes, opposing ones like the ecological, economic and management interests.

The response to the arrival of water primrose *Ludwigia grandiflora* and 'killer shrimp' *Dikerogammarus villosus* in Great Britain.

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The Invasive Non-Native Species Framework Strategy for Great Britain[1] provides a national policy framework for invasive species management. No single organisation has been identified as having responsibility for invasive species management in Great Britain. Instead, responsibility is shared across a wide variety of government and non-government bodies, relevant sector groups and volunteer groups.

The Environment Agency has responsibilities for environmental regulation, flood risk management and enhancing biodiversity in England and Wales. It tends to take leadership for coordinating action against aquatic invasive non-native species, particularly if their impact is a perceived threat to Good Ecological Status as described within the Water Framework Directive.

The responses the Agency promotes depends on the threat the species presents and the current extent of its distribution. We invest in biological control research to target well-established invasive non-native plants, such as Japanese knotweed *Fallopia japonica* and floating pennywort *Hydrocotyle ranunculoides*. Species that are at an early stage in their colonisation are targeted with early intervention programmes, either to eradicate or contain their spread depending on the viability of the control methods at our disposal. Two such species are water primrose *Ludwigia grandiflora* and 'killer shrimp' *Dikerogammarus villosus*.

L. grandiflora was introduced into GB as an ornamental plant for ponds and aquaria. Based on the impact it has had on wetland habitats on the Continent, we concluded that it should not be allowed to become established in the British environment. The Agency is coordinating an eradication programme which is currently treating the nineteen sites at which this plant has been recorded in the wild. We obtained a voluntary ban on the sale of *L.grandiflora* by the aquatic plant trades' organisation and supported a government-led publicity campaign, 'be plant wise' to educate gardeners on the identification and safe disposal of pond plants. In 2010, a government-backed review[2] identified an anticipated cost of £73,000 for the early eradication of L.grandiflora, compared to an anticipated cost of £242 million, if it were allowed to fill its niche.

The Ponto-Caspian shrimp *D.villosus* presents a different challenge. It is currently recorded from four locations in Britain. The size and sensitivity of these sites precludes eradication attempts, based on the methods we currently know to be effective. Our management response has been to attempt to contain *D.villosus* by risk-assessing the potential pathways of spread and encouraging appropriate biosecurity. Another government-led publicity campaign 'check-clean-dry' has encouraged anglers and boat-users to inspect, clean and dry their equipment between use. Although the campaign was instigated by the arrival of *D.villosus*, the campaign covers a broad spectrum of plants animals and the diseases they may vector.

We are developing pathway action plans to reduce the risk that further Ponto-Caspian species, such as quagga mussel *Dreissena bugensis rostriformis*, will invade and spread throughout Britain.

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The argument for classical biological control of invasive weeds in Europe – an aid to decision making

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Classical biological control (CBC) of alien invasive weeds is a well-established approach to weed management but one that is underutilised in Europe. The potential targets, and the reasons for a lack of take-up so far, were dealt with by Sheppard *et al*. (2006) long before the release of the Japanese knotweed psyllid in the UK, the first officially sanctioned release of its kind against weeds in an EU Member State. The pathway for such a release is now clearer (Shaw *et al*. 2011). Since then the authors have explored opportunities in the EU and have encountered various arguments for and against this strategy. This paper presents the case for CBC of weeds under the following areas of consideration: regulatory; economics; human health; safety; environmental and public perception whilst considering counter-arguments where appropriate.

This assessment reveals the real issues facing those wishing to implement CBC in a new region with a population and its representatives that are largely unaware of the potential benefits and inherently precautionary in approach. We summarise the main drivers for change in approach as being:

1. regulatory - such as the Sustainable Use Directive, Water Framework Directive and the eventual EU Instrument for invasive species
2. economics - attempting to manage invasions that are traditionally deemed out of control (by those with little knowledge of CBC) is extremely costly. The removal of water hyacinth from the Guadiana River in Spain at a cost of €21-million, is a case in point.
3. Human health and food security- as the vast scale of the invasion of*Ambrosia artemisiifolia* is regarded as effectively unmanageable using traditional methods yet this species has a toll on human health as well as agriculture
4. preserving biodiversity- environmental studies showing the negative impacts of invasive non-native weeds are on the increase showing impacts on individual species, habitats and ecosystem processes

The case against weed CBC is largely driven by risk aversion, often by people who have little knowledge of the safety record and testing procedures of weed CBC. Most stakeholders, when presented with the full agent selection/rejection and safety testing process for the Japanese knotweed psyllid, are pleasantly surprised by the amount of research carried out and the level of specificity shown by the proposed agent. In most cases people consider the small potential risks acceptable when asked to balance them against the potentially vast benefits.

CBC of weeds has an exemplary safety record and the few occasions of unintended consequences are very well documented and largely preventable in the current systems. In contrast the manual weed management, as currently used on riparian systems in much of Europe, has inherent collateral damage which is largely ignored. There are no guarantees in biological systems but it would seem that deciding on classical weed biocontrol is a small risk worth taking.

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Adelges tsugae Annand biological control program in the eastern United States: first field trials of a new predator, *Laricobius osakensis* Montgomery & Shiyake (Coleoptera: Derodontidae)

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Adelges tsugae is the single greatest threat to hemlock forests in the eastern North America. Since its introduction, it has spread throughout 50% of 1.3 million ha of *T. canadensis* ecosystem *and* it seems to only be slowed by low temperatures (USDAFS 2011). A recent genetic analysis of *A. tsugae* established Japan as the origin of the population present in the eastern US (Havill *et al*. 2006). Foreign exploration in the pests' native environment identified *Laricobius osakensis* as a key predator (Lamb *et al*. 2008). *L. osakensis* shows great promise as a valuable addition to the natural enemies community. It has been found to be a highly specialized predator of *A.tsugae*, and, considering all life stages, showed a higher numerical and functional response than *L. nigrinus*, a congeneric predator previously introduced for the control of *A. tsugae* (Vieira *et al*. 2011, 2012). Adult predators' survivorship, feeding and reproduction were evaluated in Saltville, VA, in 2011. Progeny survivorship, feeding and development were evaluated in Mountain Lake, VA, in 2012. For each sampling period, 4 (2011) or 9 (2012) branches from each of 5 trees received one of two treatments: caged hemlock branches with predators (2 or 6 branches), or caged hemlock branches without predators (2 or 3 branches). For the adult studies, *L. osakensis* survived from December to April. Females laid eggs during the entire sample period, with the highest numbers in March and April. Females produced up to a maximum of 34 eggs during a 15-day period. *A. tsugae* densities on branches with predators were significantly lower than branches without predators through most of the sampling period (Table 1).

Table 1. Comparison of number of dead *A. tsugae* in cages with predators and number of dead *A. tsugae* in cages without predators (predator), and survivorship for the progeny and the adults short and long term sampling dates. Comparison of mean number of eggs laid per female in short-term and long-term trials. Indication of mean development time from egg laying to mature larvae in the field. Sampling periods with asterisks or different letters were significantly different at *P*-value < 0.05.

Trial	Sampling date (mm.dd.yy)	Mean predation ± SE	Survivorship (adults) / Hatching (progeny) (%)	Mean # eggs ± SE	Mean developmen t time (egg laid - mature larvae) ± SE (days)
Adults short-term	01.07.11	22.3 ± 2.7*	70 ab	0.7 ± 0.5 a	-
	01.22.11	9.7 ± 2.3*	45 ab	0 ± 0 a	-
	02.05.11	25.2 ± 3.2*	85 ab	7.9 ± 1.8 b	-
	02.19.11	61.1 ± 6.1*	70 ab	7.4 ± 1.8 b	-
	03.07.11	75.6 ± 11.9*	85 ab	15.6 ±2.4 c	-
	03.23.11	43.2 ± 6.8*	80 a	16.9 ± 3 c	-
	04.09.11	31.9 ± 7.1*	70 ab	24.4 ± 1.9 d	-
	04.23.11	4.5 ± 1.2*	35 b	16.9 ± 1.7 c	-
	05.09.11	5.0 ± 2.2*	35 b	5.8± 3.5 b	
Adults long-term	02.20.11	153.1 ± 32.68*	80 a	36.7 ± 4.2 a	-
	04.23.11	146.6 ± 35.43*	0 b	34 ± 7.9 a	-
Progeny	04.01.12	28.6 ± 0.9*	21 a	-	-
	04.08.12	44.6 ± 1.9*	21 a	-	48.1 ± 0.7

The impact was especially significant in the long-term cages where the impact of both adults and larvae was observed. In the cages where enough prey were available, larvae were able to complete development. For the progeny studies, of the 7 eggs placed in the cages an average of 23.4 % hatched and developed. Of these larvae, only 2 (6.7 %) died before reaching maturity, 50% were in the 4^{th} instar, and 43.3 % had reached maturity by the end of the trial. The low hatching percentage is probably related to the extensive handling and cold storage of the eggs prior to the trials. After 21 days, the larvae were on the 3^{rd} or 4^{th} instar and each disturbed an average of 28 ovisacs. After 28 days, the larvae were mature or on the 4^{th} instar and each disturbed an average of 44 ovisacs. There were significantly more disturbed ovisacs on branches with predator eggs than in branches without predators (Table 1). Ovisacs disturbed by the larvae are clearly distinctive with all the wool spread around, the eggs exposed and some or all consumed. In the caged branches without predator eggs, none of the ovisacs were disturbed (therefore eggs were not exposed) and no other predators in any stage were found. In conclusion, *L. osakensis* can survive, feed, reproduce and develop on *A. tsugae* in southwest Virginia.

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Giant Reed in a Cory´s Shearwater breeding habitat using Decision Support System Model for the decision making

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Vila Franca do Campo Islet is located in the Natural Park of São Miguel and it is an important breeding area for Cory’s Shearwater (*Calonectris diomedea*). 30% of the 7 he is occupied by Giant Reed (*Arundo donax*) that often blocks the entrance of *C. diomedea* burrows and suppresses native vegetation. In 2009 a LIFE project NAT/P/00649 was initiated. The project’s goal was to evaluate the feasibility of restoring habitat for seabirds. Between 2009 to March 2010 we installed 90 plots/m^2 to test 3 treatments of *A. donax* control and to select the best treatment with lowest cost. The treatments were adapted to *C. diomedea’s* life cycle and to the weather and ecological restrictions. Based on the limitations, two models were tested. The first was a traditional model that consisted of cutting stems and biomass removal (treatment 1). The second approach, the integrated model, combines stem cutting, biomass removal and foliar applications of 5% herbicide on resprouting shoots. To reinforce the herbicides´´ effectiveness, a second application was made in October when *A. donax* begins to move photosynthate into its roots at the end of its breeding cycle. Two concentrations were used: 1.5% (treatment 3) and 3% (treatment 2). A lower concentration was applied in order to reduce the cost (i.e. quantity of herbicide used) and to decrease possible detrimental impacts on seed germination of native plants. GLM (binomial distribution, LOGIT link function) was used to select the best treatment based on the number of re-sprouted shoots after 1 year of *A. donax* control. The factors included in the model were time, treatment and the interaction between them. The Simple Additive Weighting (SAW) model was used to select the best treatment with lowest costs (was record cutting time, the spraying time and amount of herbicide used). The tests demonstrated that the integrated treatment model is the best method for *A. donax* control, though the results do not make it clear which combination of herbicide treatments produce the best results. Running SAW model, treatment 3 is the model that reduces 92% of *A. donax* with a cost of €0.66/m^2. *A. donax* eradication in natural areas has been attempted for decades. Although the cost of this control technique may be higher (€8000/he) it results in an immediate regrowth of native vegetation, thus improving both the habitat quality of *C. diomedea* (after controlling 1,35 he of *A. donax* were detected 319 potential nests witch 101 of these had eggs or chicks).

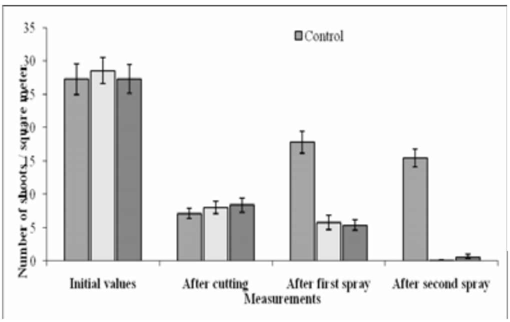

Figure. Number of *A. donax* shoots re-sprouting after control efforts. Mean of stems per plot. TA – treatment A (5% foliar application followed by second foliar application of 3%); TB – treatment B (5% foliar application followed by second foliar application of 1.5%); TC – treatment C (cut stems). t0 - before the *A. donax* control; t1 –5weeks after cutting; t2 – 5 months after the first foliar application of herbicide; t3 – 5 months after the second foliar application of herbicide.

Evaluating barriers to native plant species establishment in coastal dune communities invaded by *Carpobrotus edulis* (L.) N. E. Br., implications for restoration

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Coastal dunes are highly vulnerable, strongly affected by the invasion of alien plants that often colonize those ecosystems with a high conservation value worldwide. *Carpobrotus edulis* (L.) N.E.Br., a species native to South Africa, is one of the most aggressive exotic species on Atlantic coastal dunes, which alters the conditions of the invaded dune (Vilà *et al*. 2006, Conser & Connor 2009) threatening the native vegetation. Although actions have been promoted its elimination they have not achieved the ultimate goal of dune restoration. Thus, understanding what happened after the removal of *C. edulis* is necessary to conserve the dune plant biodiversity.

In order to understand this process, (i) we tested whether *C. edulis* alters soil chemistry causing residual effects on soil; (ii) we examined how these soil properties changes would result in lowered germination, survival and growth of *Malcolmia littorea*, a common native dune species. One year after removal the exotic plant, (iii) we analyzed both the soil properties and the soil extracellular enzyme to test the recovery of soil microbial community. Finally, (iv) we recorded biodiversity to know what species could establish after removal of the invasive.

C. edulis lowers soil pH, Ca and Na content and increases organic content, salinity and nitrogen and phosphorus concentration. *C. edulis* had strong negative effect on germination and survival of *M. littorea*. After removal of the invasive, plants rapidly colonize the treated area, but the most of native vegetation is not present. This opportunistic species that occupy the treated dunes and compete with the native dune plants in a new scenario (soil properties changes) could be the reason for restricting the native establishment. This could be the reason why had-pulling action has not reached the goal of restoration in coastal dunes after the removal of *C. edulis*.

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Assessing marine bioinvasion hazards in high-Arctic Svalbard

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Shipping to Polar regions for tourism, research and trade is expanding. Combined with climate warming, this increases the potential for marine species introduction and establishment. The high-Arctic archipelago Svalbard supports a diversity of shipping interests including ship-borne tourism, marine research, fishing, and cargo and coal transport. Bioinvasion hazards posed by ballast water discharge are acknowledged in the Norwegian Arctic through the Norwegian Ballast Water Regulation. To date, the efficacy of this regulation remains unchecked. Furthermore, the potential for species transfer to occur through transport on vessel hulls (biofouling) to Arctic regions has received little recognition. By undertaking a pathway analysis, we investigated the potential for ships to mediate species invasion in Svalbard. We collected vessel traffic data and ballast water samples, and undertook hull surveys using an ROV with the aims of: 1) obtain a measure of propagule pressure and species composition associated with vessel traffic; 2) assess the potential for species survival in Svalbard; 3) and evaluate ongoing management practices. Of the vessels discharging ballast water sampled, five undertook ballast water exchange *en route* to Svalbard, while three reported undertaking no form of exchange. Enumeration of samples is in progress. High survival rates of organisms in ballast tanks that did not undergo any form of ballast exchange, and high numbers of live organisms in ballast tanks that did undergo ballast water exchange, were noted. Biofouling was recorded on ten (83%) of the vessels surveyed, of which five (41%) had extensive biofouling. Biofouling extent was positively associated with older antifouling paint, slower vessel speeds, and longer layover periods in port. Survival experiments undertaken under laboratory conditions demonstrate that both coastal and oceanic organisms transported in ballast tanks can tolerate local Svalbard conditions. Measures of environmental similarity based on temperature and salinity suggest, however, that there is a low risk of ballast-mediated bioinvasion, whereas current shipping patterns indicate a higher invasion risk associated with biofouling. The same measures of environmental similarity adjusted to predicted temperatures determined by the IPCC under the A2 warming scenario indicate that the risk of transferring species adapted for survival by both ballast water discharge and biofouling will increase towards the end of the century. This study identifies that bioinvasion hazards posed by vessels are not adequately addressed by current management. We demonstrate that there is a need to adopt management practices that reflect regional variation in shipping traffic, and better account for bioinvasion hazards.

The role of touristic harbors in the distribution of invasive caprellids (Crustacea: Amphipoda) in the Iberian Peninsula and Northern Africa

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Marinas are critical entry points for non-native species and may act as reservoirs for introduced species promoting the secondary spread of them via recreational ships. Caprellid amphipods, commonly known as skeleton shrimps, are small marine crustaceans that are very successful in artificial hard substrata, being one of the dominant groups in the macrofauna associated with fouling communities in harbors, including biofouling on ship hulls in which it can be dispersed long distances. We use the abundance and ecological patterns of the invasive caprellid *Caprella scaura*, Templeton 1836, first recorded in the Iberian Peninsula in July 2005, as a model to understand the influence of marinas in the distribution and secondary dispersal of alien species which are introduced via ship fouling. The study was conducted between June 2011 and July 2011. We gathered biological and physical-chemical data at 88 marinas distributed along the whole Iberian Peninsula and Northern Africa. The results of this survey confirm an extensive distribution of *C. scaura* along the Mediterranean coast of Spain, more saline and warmer than the Atlantic coast of Iberian Peninsula, where another species was dominant, the native caprellid *Caprella equilibra* Say, 1818. We have only detected a clear overlap between both species in the transitional area of the Strait of Gibraltar, including the southern coast of Spain and North Africa, characterized by a mixture of waters from the Mediterranean Sea and the Atlantic Ocean. In this particular area we found two established populations of another non-native caprellid, the tropical *Paracaprella pusilla*. Abundances of *C. scaura* were very high in areas with a high Index of Recreational Port Capability (RPCI), indicating high frequencies of small craft movements and offer additional evidence in support of recreational boating as an important vector for secondary spread of non-native caprellids. No individuals were found at low salinities, when marinas were situated at the mouth of a river. The increase of recreational boating pressure in combination with environmental factors, like high temperature or salinity, may explain the rapid expansion of non-native caprellid species when they are introduced in a new area.

Who is the most endangered of them all? Analysis of tree species vulnerability to alien pests and pathogens in Europe

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Alien invasive pests and pathogens (AIPP) of forest plants threaten biodiversity and reduce timber production. Forest ecosystems may be fundamentally changed by the impact of AIPP. Moreover, compelling evidence, based on global trade patterns, indicates that the magnitude of this threat is increasing globally. Many recent papers take into account the impact of invasive species on ecosystems, but there are no studies dealing with the vulnerability of tree species to AIPP. The aim of this study was to list and rank the most vulnerable forest and ornamental wood species in Europe.
We analysed data obtained from the EPPO database of interception of AIPP and from the DAISIE and FORTHREATS databases of established of AIPP. Interception data were divided according to their pathway of arrival: plants for planting and wood, which included packaging, canes and wooden objects. Host vulnerability to established organisms was analysed for pests and for pathogens separately.
The most intercepted organisms on plants for planting pathway are nematodes, insects and fungi, these last at an increasing rate. Several ornamental shrub species are the main host on which these organisms are intercepted. Insects are mainly intercepted on the wood pathway, while all the other classes of organisms are almost absent. Ornamental and forest trees are the preferred hosts of established forest pests and pathogens. Broadleaved species are increasingly attacked by AIPP, while the rate of attack of conifer species has declined in the last decades. Global warming has made it possible for an increasing number of thermophilic AIPP to settle in Europe, colonizing tropical and subtropical tree species.

Telling a different story: a global assessment of bryophyte invasions

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In contrast to vascular plants, for which invasion patterns and driving forces are heavily studied, global bryophyte invasions have so far attracted only little attention. By using data from 82 regions from five continents of both hemispheres, we aim for the first global assessment of bryophyte invasions. We identified 137 bryophytes species which we consider to be alien in at least one of our study regions (104 mosses, 28 hepatics and 5 hornworts). Numbers of average alien bryophyte species are higher on islands than in continental regions of similar area, and peak on maritime islands of the Southern Hemisphere. Cumulative numbers of first records have grown slowly until 1950 but since then strongly increased.
The most important introduction pathways constitute unspecific, accidental import as hitch-hiker (34 species) or with ornamental plants (27 species). Compared to other taxonomic groups there is a remarkably high contribution from distant donor regions to alien bryophyte floras, especially from the other hemisphere. Most alien bryophytes display a strong affinity to strongly modified habitats (e.g. ruderal vegetation, roadsides, lawns), and only few natural ecosystems (forests, rocks) are regularly invaded. Evidence of ecological impact of bryophyte invasions is relatively low, with few species being known to competing with natives or vascular plant seedlings. Bryophyte introductions are difficult to control, identification of species needs expert knowledge, long-distance dispersal and thus re-immigration is likely to be frequent, and due to their small size most management measures are difficult and costly to apply. Therefore only few management options with limited applicability are available.
Our assessment of the global state of bryophyte invasions provides the basis for a future more explicit consideration of this largely neglected taxonomic group in invasion ecology. This seems much needed, as bryophytes differ profoundly in many respects from vascular plants and so do the patterns and underlying processes in their invasions. This study provides clear evidence that given recent trends, we can expect that numbers, abundance and associated impacts of alien bryophytes will increase considerably in the future

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Alien plants introduced by different pathways differ in invasion success

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Understanding the dimensions of pathways of introduction of alien plants is important for regulating species invasions, but more information is needed on the efficiency of particular pathways in terms of their success in delivering species. By analyzing pathways of introduction and different measures of post-introduction invasion success of 1007 neophytes, plants introduced after 1500 A.D. to the Czech Republic, we show that individual pathways affect how species introduced pass stages along the naturalization-invasion continuum, from casual to naturalized to invasive. Pathways associated with deliberate species introductions with commodities (direct release into the wild; escape from cultivation) and pathways whereby species are unintentionally introduced (contaminant of a commodity; stowaway arriving without association with it) are contrasting modes of introductions in terms of invasion success. The proportion of naturalized and invasive plant species among all introductions delivered by a particular pathway decreases with a decreasing level of direct assistance from humans associated with that pathway, from release and escape to contaminant and stowaway. However, although direct-assistance pathways result in easier naturalization and invasion, species that reach invasion stages via unintentional pathways are as widely distributed as deliberately introduced species, and those introduced as contaminants even invade a wider range of seminatural habitats. This implies that various measures of the outcome of invasion process, in terms of species' invasion success, need to be considered when evaluating the role of and threat imposed by individual pathways, and that invasions by unintentionally introduced plant species need to be seriously considered by management.

The influence of quantity, quality and distances of seeds dispersed by different vectors on the dynamics of ragweed invasion

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Common Ragweed (*Ambrosia artemisiifolia* L., Asteraceae) was unintentionally introduced from North America to Europe in the 19th century. In Austria it took more than 100 years (first documented occurrence: 1883 in Innsbruck) that the species turned from an accidental or very local weed to an invasive plant with severe impact on humans health and economy. Several vectors for the spread of this species were listed in the literature but only few data were available about the quantity and quality of dispersed ragweed seeds. The diaspores (one-flowered heads) show now specialization for any dispersal vector. Therefore it depends on containments transported by man or abiotic vectors (water). Our aim was to identify the importance of different vectors for the successful dispersal and viability of ragweed seeds.

Several studies documented since 2005 the amount of seeds dispersed by traded feed for animals. Only few authors checked also for the viability of those seeds finding that only low percentages are able to germinate. Nevertheless every year several populations establish throughout Europe from such sources. Only in Lithuavia, Poland and recently in Austria imported or even certified crop seeds were tested for contamination with ragweed. Indeed only 0.86 % of 30000 tested Austrian seed containments turned out to be infected with ragweed. Several thousand ragweed seeds were found on contaminated harvesters that were active on different crop fields. Such reapers move throughout Austria following the ripening gradient of crops and disperse high numbers of viable ragweed seeds at the regional scale.

Non-agricultural habitats like roadsides turned out to increase significantly with respect to number and density of ragweed populations, i.e., in Middle Europe. Most plausible vectors are trucks that transport contaminated seeds from infected to non-infected regions throughout Europe. Less important seems to be the direct transport of seeds via tires and wind slip. But most highly responsible for the regional transport of ragweed seeds along the highways and other arterial roads turned out to be the mowers and choppers that are used to keep the vegetation on roadsides low. Hundreds of (viable) ragweed seeds were found to stick on the contaminated machineries.

Consequently the costly cleaning of harvesters, mowers and choppers must be established as a rule to approach sustainable control of common ragweed in agricultural as well as non-crop habitat types.

Genetically engineered *Brassica napus*: a next generation weed?

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A frequently recognized concern of the cultivation of genetically engineered (GE) plants is the transfer of transgenes from GE-crops to other crops or to their wild relatives by vertical gene flow, possibly leading to increased weediness of introgressants or feral crop plants (Wolfenbarger & Phifer 2000). Environmental risk assessment related to gene flow, has long focussed on evaluating the exposure component of risk, i.e. the mechanisms and probabilities of transgenes escaping controlled systems and establishing in the environment, whereas the hazard component of risk, i.e. increased fitness and invasion potential of feral crops or recipient wild relatives, is generally simply assumed or evaluated theoretically. In 2011 we surveyed the presence of genetically engineered glyphosate tolerant oilseed rape (*Brassica napus* L.) in some of the most important Swiss railway stations, as railways represent a highly interlinked habitat with numerous possibilities for accidental entry of oilseed rape due to seed spill, and where glyphosate is regularly employed to control the vegetation, increasing the possibility of establishment for plants resistant to it. Our objective was to detect accidental establishment of GE-plants, and evaluate the ecological en economic consequences of such a presence, since Switzerland does not import nor cultivate GE-oilseed rape. 1242 oilseed rape individuals were tested for genetic modification in 39 railway stations in Switzerland and the Principality of Liechtenstein. At the Railway station of Lugano, 21 plants expressing the CP4 EPSPS protein (conferring glyphosate tolerance) were detected, presumably representing the first European record of an uncontrolled environmental presence of GE-oilseed rape. In spring 2012, another 39 GE-glyphosate tolerant oilseed rape plants were discovered in three localities on railway and port infrastructure in Basel (Switzerland). All these populations were probably introduced through contaminated seed spills from freight trains or during the transfer of goods, and underwent selection by herbicide treatments. Railways represent an ideal system for herbicide resistant transgenic plants to establish and spread. Crop-to-wild gene flow can occur as we found several sexually compatible species growing sympatrically with oilseed rape. Eradication of GE-plants inadvertently present in the environment is a legal requirement in Switzerland, and the impossibility to control feral oilseed rape populations on railway infrastructure by conventional means, directly produces additional management costs. GE-oilseed rape has shown to be a successful coloniser of new habitats in Switzerland and elsewhere (e.g. Nishizawa *et al*. 2009), causing measurable economic damage on railway infrastructure and putative ecological and economical damage in cropping systems and natural habitats, it may therefore be possible to consider it similar to an invasive neophyte. This presentation is an attempt to bridge the scientific field of environmental risk assessment of GE-plants with the field of biological invasions.

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Invaders are more often mycorrhizal, but flexible species are more wide-spread

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While mutualistic relationships can potentially be beneficial for alien plant invaders, they also bear the disadvantage that the appropriate mutualist needs to be present. We were therefore interested in whether (1) different mycorrhizal statuses (i.e., depending on mycorrhiza, being independent of mycorrhiza or being flexible that is both, mycorrhizal and nonmycorrhizal status were observed) occur with different frequencies among alien and native species, (2) mycorrhizal status affects the invasion success. We used data from MycoFlor (a database with information about mycorrhizal status for 1758 species; Hempel *et al*. in prep.) on mycorrhizal status, from BiolFlor (www.ufz.de/biolflor) for invasion status and FlorKart (www.floraweb.de) for frequency of occurrence. Associations were statistically tested using log-linear models for contingency tables and ANOVA for continuous response data. Frequencies in mycorrhizal status did not differ between natives and archaeophytes. Compared to natives, there is a higher proportion of mycorrhizal neophytes than expected but a lower proportion of non-mycorrhiza or flexible species. Similarly, invasive neophytes have a higher proportion of mycorrhizal and a lower of non-mycorrhizal and flexible species than non-invasive neophytes. This pattern is more or less robust, regardless of the type of mycorrhiza (mycorrhiza in general or arbuscular mycorrhiza specifically). Flexible species, however, are more wide-spread in each of the groups than inflexible (obligately mycorrhizal or obligately non-mycorrhizal) species. These results suggest that the invasion process of plant species is supported by the ability to form mycorrhizal symbiosis.

Unraveling the life history of successful invaders

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Despite considerable current interest in biological invasions, the common life history characteristics of successful invaders remain hard to identify. The widely-held hypothesis that successful invaders have high reproductive rates has received little empirical support (Lewontin 1965, Pimm 1991), however alternative possibilities have rarely been considered. Combining a global comparative analysis of avian introductions (> 2,500 events) with demographic models and phylogenetic-based methods, we show here that although rapid population growth may offer advantages during invasions under certain circumstances, more generally successful invaders are characterized by breeding strategies in which they tend to give priority to future rather than current reproduction. This is to be expected because high expected future breeding success reduces the costs of a reproductive failure under uncertain conditions and increases the opportunities to explore and respond to novel environmental pressures (Saether *et al*. 2004, Stearns 2000, Williams 1966). Life history thus seems to influence invasion success but by mechanisms different from those usually considered in the literature.

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The global garlic mustard field survey: first results from a large-scale collaborative project in invasion biology

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A fundamental goal of invasion biology is to identify the ecological and evolutionary factors that allow for the successful establishment and proliferation of species introduced to novel areas. A growing number of hypotheses attribute this invasion success to biotic differences between native and introduced ranges. Many of these hypotheses assume that introduced populations are generally larger, with higher rates of survival and reproduction, relative to native populations. However, the empirical evidence for this increased performance is in fact still scarce. Most previous studies examined just few native and introduced populations, in which case any differences could simply be due to environmental heterogeneity rather than true biological differences between the native and introduced range.

To test the hypotheses of increased vigor thoroughly for one of the most problematic plant invaders of North America, garlic mustard (*Alliaria petiolata*), we designed a unique collaborative global field study based on a simple sampling protocol, which was implemented by a large number of professional scientists, students, educators and private citizens across Europe and North America. During 2009-2011 we surveyed over 500 natural populations for population and plant sizes, plant densities, and levels of herbivore and pathogen damage.

First results indicate that as predicted, populations were larger and more dense, at least at the rosette stage, in the introduced than home range (Figure 1). However, other population parameters, such as adult density, did not differ between the introduced and home range, and some even showed patterns that were opposite to our expectations, such as individual plant sizes and herbivore damage (Figure 1). More in-depth analysis of these data will, in addition to origin status, incorporate spatial autocorrelation, as well as population differences in climate and habitat.

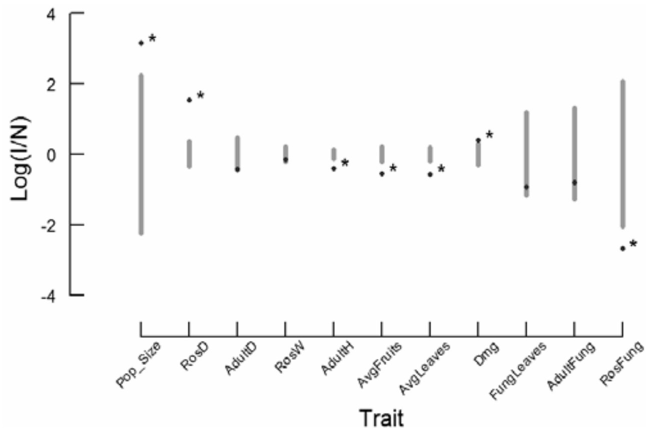

Figure 1. Comparison of field measurements in introduced (I) and native (N) regions. For each trait, the log-difference of introduced vs. native regions (red dots) is compared to a null distribution generated by permuting populations across regions for 10,000 iterations. Significant deviations from the 95% confidence interval (grey bars) of each permutation test are indicated by asterisk. Traits include population size (Pop_Size), rosette density (RosD), adult density (AdultD), rosette width (RosW), adult height (Adult H), average fruits per plant (AvgFruits), average leave per plant (AvgLeaves), herbivory damage (Dmg), levels of fungal infection on leaves (FungLeaves), fungal infection on adults (AdultFung), and fungal infection on rosettes (RosFung).

The role of soil seed banks in plant species invasions

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The questions whether the invasion success of an alien plant species depends upon a certain suite of species traits (invasiveness) and/or upon the characteristics of an ecosystem, including differences in species traits and phylogeny between native and alien plants (invasibility), have been prominent topics of invasion ecology since its rapid development in the 1980s. Increasing evidence indicates that there is a suite of traits that affects the success of species introduced outside their native range. Promising traits, albeit not sufficiently explored due to poor availability of data, include a capacity of an alien species to form a soil seed bank and/or to alter substantially the characteristics of the soil seed bank of resident communities. Here, we present preliminary results of a large study aimed at investigating comprehensively the role of soil seed banks in plant invasions, focusing on four main research questions: (1) whether the seed bank of an alien species differs in its native and alien range across ecosystem types; (2) whether the seed banks of invasive species differ from those of congeneric species (invasive vs. non-invasive species of the same genus), thus allowing for eliminating any phylogenetic bias; (3) whether the seeds bank of alien species differ from those of native/resident species; and (4) what is the impact of invasive plants on seed banks of resident communities across ecosystem types. We will present the results of analyses of primary data and of a meta-analysis study of the impact of invasive plant species on resident seed banks. Data to answer questions 1–3 will be based on the North West European seed bank database compiled by Thompson *et al*. (1997), summarising information on the seed bank of 1189 temperate plant species derived from 275 primary studies until 1994. So far, we added over 2000 records to this database, based on studies published after the mid-1990s. For each species' seed bank record, we added information on (i) region of collection and sampled species' native range; (ii) native or alien status of the species sampled, and, where available, whether it is casual, naturalised or invasive in the region; (iii) ecosystem type in which the data were collected, and (iv) the sampled species' global invasive status, using the Invasive Species Group database. For each species, we also added data on a number of traits, including life strategy, growth form, and, where available, seed size and seed bank type (persistent vs. transient). This dataset now includes 11670 records, with information for 1457 species, belonging to 638 genera and 145 families. Of those species, 114 are listed in the Invasive Species Specialist Group database. The results of this study are central to improving our understanding of the role of seed bank in plant invasions across ecosystem types.

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Proteaceae introductions and invasions: what types of species are introduced globally, and which traits are associated with invasive success?

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The angiosperm family Proteaceae provides an excellent study group for identifying the determinants of invasiveness in woody plants, since many species are used as cut flowers, for hedges and ornamental plants, in landscaping and for food, and consequently have had a long history of introduction to regions outside their native ranges. Here we determine which Proteaceae have been introduced, and which traits separate those species that have been introduced from those that are known to be invasive. We first created a standardized species list of 1709 Proteaceae species belonging to 79 genera, then, developed a database of species that have been introduced worldwide. Overall, we examined records from 27 sources which comprised herbarium specimens, online databases (i.e global compendium of weeds and global biodiversity information facility) and literature sources (i.e Flora Europaea and the cultivated plants of Southern Africa). A synopsis of our findings is illustrated in Figure 1. We analysed various explanatory variables (including seed mass, height, life form, age to maturity, length of flowering, survival mechanism, serotiny, dispersal vectors, pollinators, susceptibility to phytophthora and native range size; and some specific traits which we used as putative indicators of horticultural demand, such as use, colour and size of blooms) using generalized additive models and regression trees. Results will be discussed in terms of traits that confer invasiveness on a global scale which are potentially useful for screening taxa. We conclude with a discussion of recently identified Proteaceae invasions in South Africa and outline potential management options.

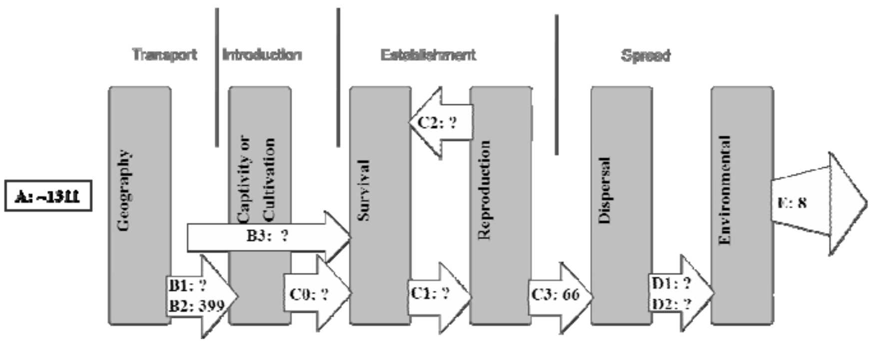

Figure 1. Number of Proteaceae introduced worldwide and their transition along the biological invasion continuum (adapted from Blackburn *et al.*, 2011).

Young leaves are better defended and less damaged in introduced versus native populations of *Verbascum thapsus*: Considering optimal defense and the "evolutionary dilemma" in the context of invasions

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Optimal defense theory predicts that resource-limited plants will deploy chemical defenses based on the fitness value of different tissues and their probability of attack. However, what constitutes optimal defense depends on the identity of the herbivores involved in the interaction. Specifically, while generalists are typically deterred by chemical defenses, coevolved specialists are often attracted to these same chemidcals. This imposes an "evolutionary dilemma" in which generalists and specialists exert opposing selection on plant investment in defense, thereby stabilizing defenses at intermediate levels. We used the natural shift in herbivore community composition that typifies many plant invasions to test a novel, combined prediction of optimal defense theory and the evolutionary dilemma model: that the within-plant distribution of defenses reflects both the value of different tissues (i.e., young versus old leaves) and the relative importance of specialist and generalist herbivores in the community. Using populations of *Verbascum thapsus* exposed to natural herbivory in its native range (where specialist and generalist chewing herbivores are prevalent) and its introduced range (where only generalist chewing herbivores are prevalent), we illustrate significant differences in the way iridoid glycosides are distributed among young and old leaves. Importantly, high-quality young leaves are 6.5× more highly defended than old leaves in the introduced range, but only 2× more highly defended in the native range. Additionally, defense levels are tracked by patterns of chewing damage, with damage restricted mostly to low-quality old leaves in the introduced range, but not the native range. Importantly, whole-plant investment in defense does not differ between ranges: thus, introduced mullein may achieve increased fitness simply by optimizing its within-plant distribution of defense in the absence of certain specialist herbivores.

Why is *Harmonia axyridis* so successful?

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The multicoloured Asian ladybird *Harmonia axyridis* Pallas (Coleoptera: Coccinellidae), indigenous in China and Japan, was introduced as biological control agent in Europe and the USA. The introduction of *H. axyridis* is now considered an unfortunate event because of its negative side effects on, e.g., non-target species, fruit production, and human health (Van Lenteren *et al*. 2008). Since its introduction, it has established and spread, and it is now regarded as an invasive alien species. The establishment of *H. axyridis* is associated with the decline of native coccinellid populations in urban, agricultural, and natural habitats in Europe and in North America (Brakefield & Jong 2011).
Several life history characteristics may contribute to the rapid spread of *H. axyridis* and its effects on native species. Little is known about its biological characteristics in the north-western European natural environment and the details of some of these traits and their exact contribution to the invasive success of *H. axyridis* still have to be unravelled.
We therefore studied the life history characteristics of *H. axyridis* under (semi-) field conditions in the Netherlands in order to gain insight into the causes and consequences of their rapid establishment. The results on overwintering survival, presence of natural enemies, intra guild predation and larval development suggest that *H. axyridis* is very successful in its exotic range (Raak-van den Berg *et al*. 2012a, Raak-van den Berg *et al*. 2012b).
High overwintering survival is an aspect of the biology of *H. axyridis* that contributes to its invasion success into a new area ((Raak-van den Berg *et al*. 2012a, Raak-van den Berg *et al*. 2012b). Developmental times of *H. axyridis* are similar to that of *Adalia bipunctata* L. (Coleoptera: Coccinellidae), however larval and pupal survival of *A. bipunctata* seems to be lower. We also show that *H. axyridis* is a strong intraguild predator (results submitted to journal).Furthermore our – ongoing – analysis of the data from literature confirms that *H. axyridis* is a very robust and cosmopolitan insect, which thrives well under a wide range of conditions.
Comparison of characteristics of *H. axyridis* with other, native coccinellid species, indicate that the above mentioned aspects (winter survival, intraguild predation, larval development and survival) of the biology of *H. axyridis* contribute to, and certainly not counteract, its firm establishment in and invasion of a new area.

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Latitudinal variation in interactions between invasive plants and their natural enemies

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Plants often lose natural enemies (herbivores and pathogens) while invading new geographic regions, as predicted by the Enemy Release Hypothesis (Torchin & Mitchell 2004). However, a similar reduction in attack may occur at a more local scale within a species' range: isolated plants may escape enemies that fail to find them or cannot maintain local populations (e.g., MacKay & Kotanen 2008). For instance, in Canada, most invasive plants occur in the south; do isolated populations near the northern edge of an invader's range escape the enemies present in more southern populations? We have investigated this issue using the non-native biennial, common burdock (*Arctium minus*), as a model species (Kambo 2012). In southern Ontario, this plant is attacked by a wide range of insect herbivores, including generalist leaf chewers as well as specialists such as leaf-mining flies (*Liriomyza arctii, Calycomyza flavinotum*) and an abundant lepidopteran seed predator (*Metzneria lappella*). Surveys over an 850 km latitudinal transect from temperate southern to boreal northern Ontario indicate that damage by all of these enemies declines sharply with latitude, while plants in more northern areas are larger and more fecund. Critically, seed parasitism drops from more than 85% in the south to less than 25% in the north (Figure 1). These results suggest that populations of *Arctium* near this species' northern limit may gain a benefit by escaping their usual enemies. As well, preliminary work has now found similar patterns for several other invaders (*Cirsium arvense, Taraxacum officinale*, *Plantago major*). Escape from enemies near invaders' range margins may accelerate further spread, including expected migration in response to climate change (Walther *et al*. 2009).

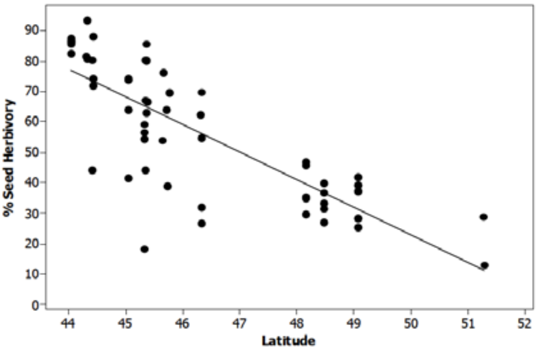

Figure 1. Significant negative regression between the percent of *Arctium minus* seeds destroyed by *Metzneria lappella* and latitude ($F_{1,55}$ = 91.68, $p < 0.0001$, $r^2 = 0.63$)

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Mycorrhizal fungi and nutrients increase performance of *Cinchona pubescens* in its introduced compared to its native range

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One of the emerging paradoxes of species invasions is that invasive species are sometimes more ecologically successful in their introduced range than in their native range. Commonly accepted mechanisms for this phenomenon include different niche opportunities. Yet these explanations are often limited by a lack of experiments directly manipulating the factors affecting the invader performance. The red quinine tree, *Cinchona pubescens*, appears to be a model species for examining this paradox as it is highly invasive in its introduced range in the Galápagos Islands, but presently rare in its native range on mainland Ecuador. Here we investigate three potential causes of differential ecological success of *C. pubescens*: the effects of nutrients (nitrogen, phosphorus), mycorrhizal fungi (MF) and origin (native – Loja, Ecuador; introduced - Galápagos) on the growth of *C. pubescens.* Previous research indicated that *C. pubescens* was more heavily colonized by MF than other native species in Galápagos, leading us to hypothesize that MF might give it a growth advantage in its introduced range. We tested this hypothesis, as well as the effects of nutrients and origin on the growth of *C. pubescens* seedlings in a greenhouse experiment. Sterile seedlings were grown with and without a MF inoculum extracted from their respective soils of origin and were then subjected to different nutrient regimes, yielding 16 treatment combinations total. Growth of seedlings was monitored over six months. The experimental seedlings were sampled for leaf nutrient analysis and for determination of the extent of MF colonization in the roots. Preliminary results indicated that overall, *C. pubescens* seedlings from Galápagos had significantly larger shoots than those originating from Loja. This applied to the MF treatment (10.3 ± 2.6 cm shoot length in Galápagos vs. 6.8 ± 2.4 cm in Loja) as well as to the non-MF treatment (9.4 ± 3.1 vs. 7.7 ± 2.4 cm) when all nutrient treatments were taken into account. Within the nutrient treatments, the application of nitrogen significantly increased the shoot length of Galápagos seedlings compared to Loja seedlings (11.7 ± 2.6 cm in Galápagos vs. 6.9 ± 2.6 cm in Loja), as did the application of phosphorus (10.0 ± 2.0 vs. 6.9 ± 2.4 cm). There were no significant differences in shoot length between the control treatment (no nutrients) from both origins, neither in the MF treatment nor in the non-MF treatment. Results strongly suggest that *C. pubescens* from Galápagos is highly capable of exploiting resources (MF and nutrients) to its growth advantage whereas the Loja conspecific is not, implying that mycorrhizal mutualism may facilitate invasion by *C. pubescens*.

The role of past and present landscape on plant invasion in the Mediterranean coast

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The role of landscape on plant invasion is a topic of increasing interest in invasion biology. This paper aims to assess the relative importance of past and present landscape in structuring exotic plant species composition, abundance and richness in various coastal habitats in the Mediterranean. The study was carried out in a 500 m^2 strip along the coast. The effect of landscape and other environmental factors on exotic plants richness, abundance and composition was investigated using GLM and CCA. The results showed that landscape properties act differently on exotic plant richness, abundance and composition. Landscape configuration (i.e. patch size and shape) is an important determinant of exotic plants richness. Landscape features, but also habitat type and patch dynamics explain the abundance and composition of the exotic plants. All landscape variables are better predictors than climatic variables in explaining the level of alien plant invasion on the Mediterranean coast. Our results highlight the major influence of landscape context and history on plant invasion, from their establishment to their spreading and distribution.

Drivers of invasive knotweed success

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A key question in invasion biology is what allows some invaders to become dominant in their introduced range. Some of the most aggressive and ecologically problematic plant invaders of the European and North American temperate zones are the invasive knotweeds *Fallopia japonica*, *F. sachalinensis*, and their hybrid *F. x bohemica*, which are extremely competitive, often form monospecific stands, and cause significant ecological and economic damage. The reasons for this invasion success are still not sufficiently understood.We present the results of a series of ecological experiments in which we tested for different mechanisms of invasive knotweed success. In all of these experiments we created artificial communities of several native European plant species growing on natural soils, which were then experimentally invaded by knotweed. Depending on the question, we manipulated different elements of our experimental system, e.g. the mean and variability of soil nutrient supply, the presence of different fractions of soil biota, or the taxonomic and genotypic identity of the knotweed. Our experimental approach thus represents a compromise between the precision of reductionist experiments and the realism of natural communities. We find that knotweed greatly benefits from the presence of soil biota, more so than any of the native species, in its early stages of establishment, that it is a superior resource competitor in particular where environments become more variable over time, and that knotweed hybrids are much more successful in invading native plant communities than either of the parental species. Allelopathy appears to play only a minor role in established knotweed stands. The success of invasive knotweed appears to be driven by a combination of ecological and evolutionary factors. In particular soil biota and environmental heterogeneity seem to play a key role.

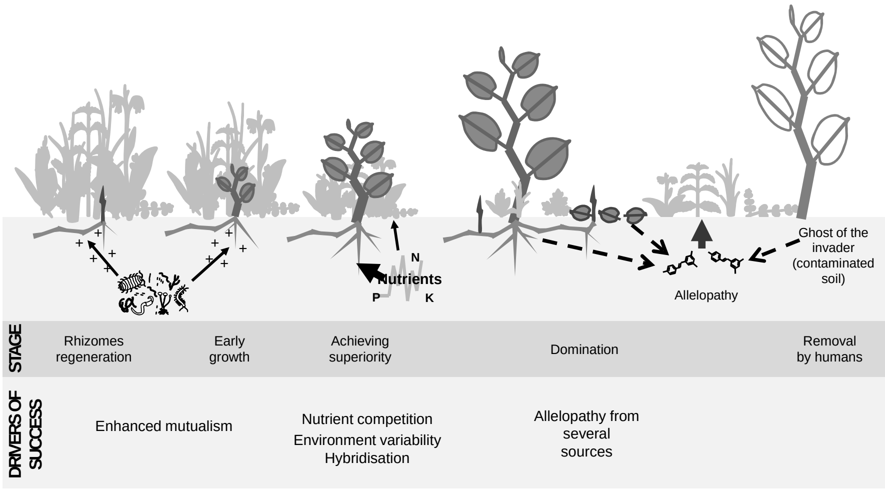

Figure 1. A hypothesis about different drivers of invasive knotweed success and their importance at different stages of knotweed establishment and spread.

How Balsams get to the top: a trade-off between adaptation and interaction

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Most invasive species show distribution limits with altitude or less abundance at higher altitudes, which holds true worldwide (McDougall *et al*. 2011). Range limits, and in the scope of climate change especially climatic limits are of high interest. Albeit invasive species actually ascent towards formerly unknown altitudes, it remains unclear which mechanisms or combinations of mechanisms promote this spread (Pauchard *et al*. 2009).
Recent studies document invasive species´ high phenotypic plasticity at altitudinal gradients (Trtikova *et al*. 2010), which should promote their spread upwards. Species´ fundamental niches often neither determine the upper limit, as growth and reproduction have been shown to occur above the observed natural range limits (Poll *et al*. 2009). Other factors preventing the spread upwards might be changed disturbance regimes or reduced propagule pressure. Biotic interactions have been shown to change drastically at altitudinal gradients (Choler *et al*. 2001) and could be a key factor in invasion limits as well. Recent studies of invasive species at higher elevations mainly focused on ruderal species and disturbed sites. Naturally, competition was not in the scope of these studies.
We investigated the upper range limits of invasive Himalayan and Small Balsam (*Impatiens glandulifera* and *I. parviflora*) in comparison to their native congener Jewelweed Balsam (*I. noli-tangere*) in natural mountain forests at a steep elevational gradient (300-1200m) in the National Park Bavarian Forest. Both invasive species established in Germany more than 150 years ago, hence actual distribution limits could be supposed to reflect steady state. A combination of mapping, trait measurements and experiment was chosen to disentangle the effects of adaptation, biotic interactions and climate.
The field survey focused on changes in species compositions and hence changes in direct competitors with elevation. Competitive disadvantages due to differences in phenotypic plasticity were investigated by measurements of several plant traits (specific leaf area, plant height, seed mass, leaf frost resistance and phenology). Influence of climate, propagule pressure, and biotic interactions were studied with a field experiment. We investigated germination and plant establishment at four different altitudes, the highest site above actual range limits of the species.
Native Jewelweed Balsam is most successful and reaches altitudes of up to 1100m, Himalayan Balsam can be found up to 900m, and Small Balsam reaches its upper limit already at around 700m. Success of the species at higher elevations seems to be linked to higher frost resistance and life-cycle adaptations (plastic phenology), while other trait measurements show contradictory results. For some of the traits measured, unsuccessful species respond even more flexible to elevation than the native congener. We show that a careful ecological interpretation of trait measurements is essential, especially when only one or two "key traits" are recorded. Germination patterns could not explain different altitudinal limits, whereas plant establishment is heavily influenced both by biotic interactions and climate. We conclude that the role of propagule pressure for range limits might be overestimated in current literature.

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Functional responses of native vs. exotic amphipods: effects of predation risk and parasitism

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Increasingly, functional response techniques are used to assess the impact of exotic species on native communities, and also the potential for parasites to alter the predatory function of their hosts. However, simple laboratory predator-prey systems with or without parasites may fail to reveal the full extent of an exotic species' predatory role. The presence of higher trophic predators in the natural environment may alter an exotic species' predatory function as a result of both the exotic species' own predation risk and behaviour modifications induced by trophically transmitted parasites. Our study focused on two freshwater amphipods in Ireland, the native *Gammarus duebeni celticus* infected with a microsporidian, *Pleistophera mulleri*, and the exotic *Gammarus pulex* infected with a trophically transmitted fish acanthocephalan, *Echinorhynchus truttae*. This exotic amphipod is known to displace native amphipods and alter native invertebrate assemblages in invaded regions. We used a four-species module approach (fish predator-amphipod predator-parasite-prey) to simultaneously investigate the influence of parasitism and predation risk on the predatory response of both amphipod species to a variety of invertebrate prey. Our results suggest that native and exotic amphipods may make different foraging choices dependent on the combined influences of predation risk and parasitism, and that this behaviour is likely to be community context dependent.

Biotic resistance, niche opportunities and the invasion of natural habitats

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Despite the current interest in the invasion process, the reasons why exotic species can establish in environments to which they have had little opportunity to adapt remain little understood. Fundamental to the establishment is that the invader finds an appropriate niche in the novel environment, yet it is unclear whether this is achieved by displacing native species from their niches and/or by exploiting niche opportunities that native species do not monopolize. In the present study, we contrasted the importance of the competition and opportunity hypotheses as explanations for the success of an exotic passerine, the Red-billed Leiothrix *Leiothrix lutea*, in a forest reserve from the Western Mediterranean basin. The invasion of Leiothrix provided a rare opportunity to assess the relative importance of each hypothesis because information on native bird abundance was available before and after the irruption of the invader. Our results yielded evidence for both the competition and opportunity hypotheses. In line with the opportunity hypothesis, the invader established with relatively little resistance or consequence for native species, reflecting the opportunist-generalist nature of the invader and that its niche requirements were poorly represented in the native community. Nevertheless, the irruption of the invader coincided with the decline of one of the native species with which resource niche overlapped to a greater extent. This decline was not caused by environmental changes, as no similar declines were observed in habitats where the invader was scarce. More likely, the decline resulted from competitive displacement by the invader, which was larger in body size and foraged in larger flocks. Thus, our results highlight that the competitive and the opportunity hypotheses should not be seen as alternative hypotheses but as explanations that combined may contribute to better understand the success of exotic species in natural environments.

Allee effects and invasion success

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Studies of biological invasions frequently acknowledge a phenomenological paradox wherein despite the amplified threats of extinction facing small founder populations, successful colonization occurs nonetheless, bringing devastating ecological and economic consequences. We addressed this paradox by exploring the importance of evolutionary processes given the time constraints generated by ecological factors driving the population to extinction. When a population is introduced at low density, individuals often experience a reduction in one or more components of fitness due to novel selection pressures that arise from diminished intraspecific interactions and positive density dependence (i.e., component Allee effects). Although the time to extinction may be limited, there is a chance that the population can adapt and recover on its own (i.e., evolutionary rescue) or through additional immigration contributing to the population size (i.e., demographic rescue) and/or enhancing the genetic variation (i.e., genetic rescue).Within a spatially-explicit modeling framework, we consider the relative impact of each type of rescue on probability of success by following the evolution of a multi-locus quantitative trait that influences the strength of component Allee effects. We demonstrate that because the ecological system is significantly density driven, the effect of demographic rescue provides the greatest opportunity for success. While highlighting the role of evolution in the invasion process we underscore the importance of the ecological context influencing the persistence of small founder populations.

A biogeographical study of the genetic adaptation and phenotypic plasticity of two invasive maple trees, *Acer negundo* and *Acer platanoides*

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Genetic adaptation and phenotypic plasticity are two mechanisms that can play a role in plant invasion. For instance, introduced populations have been found to exhibit greater dispersal ability, faster growth, greater physiological abilities and increased plasticity compared to populations from native ranges (Bossdorf *et al.* 2005, Flory *et al*. 2011).
In addition, invasion by woody species can lead to serious changes in ecosystem functions such as primary production, biomass distribution and decomposition rates (Richardson & Higgins 1998). Consequently, invasive alien tree species have become a major concern around the world and many of them are now listed among the most damaging invasive species (Richardson & Rejmanek 2011). However, all the invasive trees have not been equally studied and species such as *Pinus spp*, *Acacia spp* and *Triadica sebifera* dominate the literature so far (Lamarque *et al*. 2011). For instance to date, the reciprocal common garden approach has been solely applied to the invasive Chinese tallow tree (*Triadica sebifera* L.). More studies are thus needed to determine the role of both genetic divergence and phenotypic plasticity in tree invasion.
Our study focused on two invasive maple trees: *Acer negundo* L. is native from North America and has invaded riparian habitats of southern and eastern Europe while *Acer platanoides* L., native from Europe, has successfully spread into deciduous forests of eastern North America. Based on reciprocal common gardens with 1460 seedlings planted in the native and introduced ranges of both species, we quantified genetic differentiation and compared phenotypic plasticity between native and introduced populations in life-history traits related to growth, phenology, leaf physiology and morphology.
We provide evidence for a strong genetic differentiation in all studied traits between native and introduced populations of *A. negundo*. For instance, introduced populations flushed later in Canada but earlier in France relative to their native conspecifics (Figure 1a). They also exhibited significant lower photosynthetic capacities (A_{area}), lower leaf nitrogen content (N_{area}) and thinner leaves (*i.e* lower LMA) in both gardens (Figure 1b-d). In contrast, no or weak differences were observed for *A. platanoides* (Figure 1e-h). Moreover, both species showed high level of plasticity for all traits whereas introduced populations of *A. negundo* also displayed greater magnitude of plasticity in phenology.
Along with a greater sensitivity to temperature, genetically-based changes in growth and leaf morphology observed for introduced populations may have favoured *A. negundo* invasiveness in southern France. In contrast, we speculate that the dynamic of invasion of *A. platanoides* in Canada has rather been supported by phenotypic plasticity.

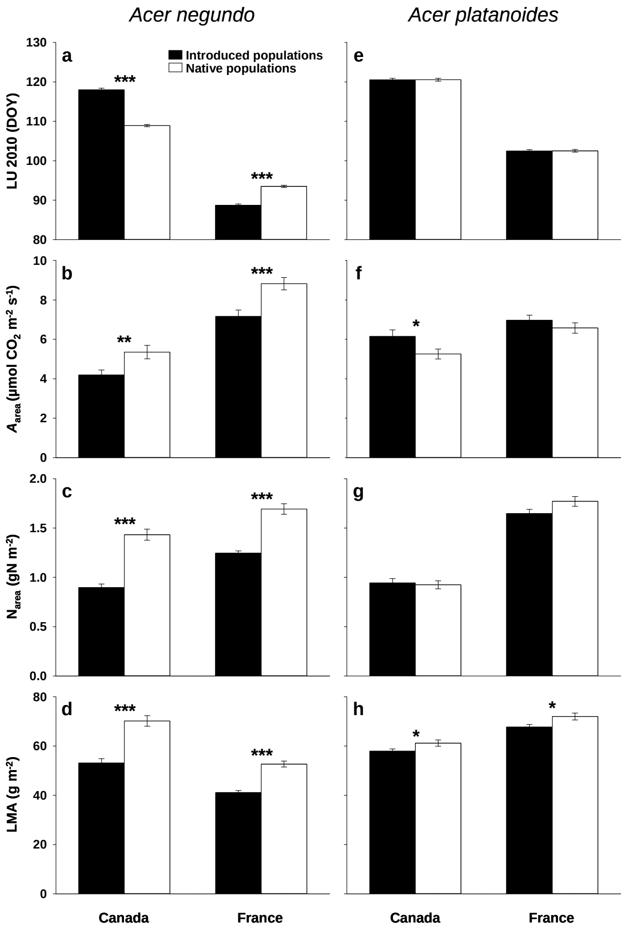

Figure 1. Differences in leaf phenology (LU), physiology (A_{area} and N_{area}) and morphology (LMA) between native and introduced populations of *A. negundo* (a-d) and *A. platanoides* (e-h) grown in two common gardens (Canada *vs*. France). Values represent means ± SE for both native and introduced ranges. See text for definition of terms
* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

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Variation in ploidy level of native and invasive populations of oxeye daisy, (*Leucanthemum vulgare* sensu lato)

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Recently, polyploidy has been proposed to play an important role in plant invasions with invasive plants being more likely polyploid than diploid (Pandit 2011). Oxeye daisy (*Leucanthemum vulgare* s. l.) is a perennial plant native to Eurasia which has been introduced to many parts of the world, as an ornamental and as a seed contaminant. The plants are naturalized throughout most of temperate North America, where oxeye daisy has become an aggressive invader in pastures and meadows. In Europe, common oxeye daisies are represented by two different cytotypes, the diploid *Leucanthemum vulgare* s. str. Lam. and the tetraploid *Leucanthemum ircutianum* DC. In order to identify the distribution and abundance of the two oxeye daisy taxa across the native range in Eurasia and the invaded range in North America, seeds of more than eighty oxeye daisy populations in Europe and western Asia and fifty populations in North America were collected. Subsequent determinations of the ploidy level revealed that although the tetraploid *L. ircutianum* is the dominant cytotype in Europe, invasive oxeye daisies in North America are almost exclusively represented by the diploid *L. vulgare*. Seeds of a subset of the populations were sown in a common garden to assess phenotypic differences in the two cytotypes from the native and the introduced range. Moreover, in the frame of a classical biological control project, field surveys have been made to compare the specialist herbivore community associated with the two different cytotypes in Europe.

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Post-introduction evolutionary change in the invasive plant *Phalaris arundinacea* can lead to critical transitions in wetland ecosystems

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The introduction of invasive plants into natural communities can affect community composition but can also alter food webs, nutrient cycling and carbon storage capacity. Why invasive plants cause disruption in the new range but are benign in their native range may be due to post-introduction evolution that can create new mean trait values as well as alter the trait architecture of the introduced individuals. We make use of a well-studied plant model system to ask what the consequences of changes in traits have for changing ecosystem processes that may lead to critical transitions in community structure and the ecological dominance of non-native species. Previous work with reed canarygrass (*Phalaris arundinacea*), an aggressive invader of North American wetlands, has shown that multiple introductions from Europe were associated with reorganization of the genetic variance, namely the emergence of novel allozyme genotypes in North America and the evolution of smaller genome size (Lavergne & Molofsky 2007, Lavergne *et al*. 2010). These genomic changes taking place during invasion have important consequences for functional traits. Invasive genotypes with small genomes consistently outperform native genotypes in common garden experiments; they grow faster, have lower respiration rates, produce more asexual tillers, produce leaf litter with higher C:N content, and attain higher overall biomass (Brodersen *et al*. 2008, Lavergne *et al*. 2010). Changes in key functional traits have the potential to trigger a critical transition in ecosystem state through positive feedback loops, resulting in the invasion and maintenance of novel genotypes into wetland communities and the loss of native biodiversity (Eppinga *et al*. 2011). Specifically, these transitions are driven by ecological and evolutionary changes in the quantity and quality of undecomposed biomass (litter), which in turn affects the availability of nutrients and light to *Phalaris* and its competitors Genetic variation and evolution in the invader for traits such as biomass production and C:N content drive two key processes: 1) the accumulation of more litter biomass in the ecosystem and 2) slower decomposition rates due to lower litter quality. When these effects act in concert, theory predicts a critical transition from a native to a non-native dominated ecosystem (Eppinga *et al*. 2011). Initial field experiments have confirmed several predictions of this model; invasive genotypes have novel traits and experience positive fitness feedbacks in experimental mesocosms and that naturally invaded communities with high *Phalaris* abundance show leaf litter with higher C:N ratios.

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Aspects of chemical and genetic diversity of invasive plants to be considered in biological control

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Within the various mechanisms that have been discussed to be involved in plant invasion, the roles of plant chemical and genetic diversity in this process are only poorly understood. Both high chemical and high genetic diversity of introduced plant populations may pose key advantages under changed selection pressures. Moreover, such diversity has eventually also major implications for biological control programs of invasive weeds. *Tanacetum vulgare* is an aromatic plant species of the Asteraceae which is native to Eurasia and was introduced mainly for medicinal purposes to North America. The plant can differ tremendously in its qualitative and quantitative composition of terpenoids, forming different chemotypes (Kleine & Müller 2011, Wolf *et al*. 2011). To assess the genetic diversity of *T. vulgare* in relation to its chemical diversity, plants originating from different populations of native and invasive regions were grown in a common garden. Inter simple sequence repeat markers indicated an increased genetic diversity in plants of the introduced compared to the native range, whereas the chemical variation was comparable between native and introduced populations. A considerable amount of unique geno- and chemotypes could be detected on both continents, but genetic and chemical data did not correlate, indicating that the genetic structure of invasive populations does not necessarily offer information on its chemical diversity and *vice versa* (Wolf *et al*. 2012). Several herbivorous species showed different acceptance of different chemotypes under common garden conditions (Kleine & Müller 2011). *Cassida stigmatica* is a beetle that specialized on *T.vulgare* and has been considered as potential biocontrol agent. We found that it prefers certain chemotypes but it accepts various chemotypes for feeding and oviposition and performs on them equally well (Wolf *et al*. in press). Overall, knowledge of both the genetic structure and the variation in plant metabolite pattern should be considered in studies on biological invasion and for biological control research.

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Demographic Performance in Native and Introduced Populations of a Perennial Plant (*Silene latifolia*)

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A biological invasion occurs when an exotic species is introduced, establishes and then spreads geographically in the new range. As such, an invasion is principally a population level phenomenon. However, a majority of studies have focused on individual level phenotypic traits that contribute to invasion success. In this talk I will present results that offer some insight into population level demographic aspects of an invasion. Silene latifolia is a perennial plant native to Europe that successfully invaded North America while escaping natural specialist enemies. A reciprocal common garden experiment conducted in multiple European and N. American sites suggest that local adaptation acting along with in situ evolution of life history traits have contributed to this plant's success. The results are discussed in context of pre-adaptation and natural selection driving successful biological invasions.

POSTER CONTRIBUTIONS

Investigating the adaptive potential of agricultural weeds to increased temperatures

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Agricultural weeds are one of the main reasons for crop reduction globally and the question of how they are affected by climate change is therefore of high importance. Increased temperatures and CO_2, droughts and extreme weather events as well as related adaptation strategies such as the cultivation of new crops will result in changes in impacts of the current weed flora of a region as well as in the introduction of new species with the potential to become agricultural weeds. Possible impacts of climate change on plants have mainly been investigated with distribution models looking at the boundaries and possible changes in range size. For agriculture, however, changes in population dynamics and abundance of weeds as well as the adaptive potential of species may be of greater importance and need to be incorporated in modelling approaches. We study the impacts of increased temperatures on the archaeophytic weed species, *Alopecurus myosuroides* in Britain. Sixteen populations of *A. myosuroides* sampled to cover the range of the species' distribution in Britain were grown in a polytunnel with temperatures artificially kept at ambient, plus 2^0 C and plus 4^0 C degrees above ambient, respectively. Within and between population variability was studied with respect to key life history events such as emergence and onset of flowering as well as the fitness of plants. We found significant differences between populations depending on their geographic origin particular for the phenological traits whereas seed production increased with increasing temperature independently of geographic origin.

The methodology also offers the potential to be used for the screening of potential newly introduced agricultural weeds as well as for species that are already present but not currently having major impacts.

Modelling the effect of climate change in plant invasion hotspots: from patterns to forecasts

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Alien plant invasion is a global threat to biodiversity and ecosystem services that can be enhanced by climate change. To provide a tool for climate change mitigation, we used data obtained from an unpublished Ph. D thesis by Campos (2010) in order to simulate invasion by alien plants in the Basque Country (Iberian Peninsula) under medium warming and drying conditions. The dataset consisted of the distribution of 89 invasive alien plant species (*sensu* Richardson *et al*. 2000) and climate and human disturbance descriptors on 104 100-squared km UTM grid.

In order to assess the consequences of ignoring uncertainties and the presence of spatial autocorrelation, we fitted and compared two models. In Model I, spatial autocorrelation and model uncertainties were deliberately ignored and we used a Poisson regression model to fit the data. In Model II, autocorrelation was removed before testing against environmental descriptors, variation was partitioned at two spatial scales, and uncertainties were introduced in the simulation.

The principal coordinates of neighbour matrices or PCNM method (Borcard & Legendre 2002) was used. We used both fitted models to simulate (and compare) alien plant invasion under IPCC climate change scenario A1B (Meehl *et al*. 2007). Prediction estimates were computed by adding an increase of 2.65ºC in mean annual temperature and a decrease of 0.35 mm per day precipitation to the temperature and precipitation baselines.

Model I explained ca. 80% of variance in the number of invasive alien plant species through mean annual temperature and human population density, although failed to detect the effect of annual precipitation. It also produced an unrealistic simulation, which was also biologically catastrophic.

This unrealism was due to ignorance of model uncertainties and to the noxious effects of the presence of autocorrelation in both the response and the explanatory predictors (Legendre *et al*. 2002).

In contrast, in Model II, climatic descriptors shaped invasion by alien plants at a broad scale, explaining only ca. 40% of variance in the response, but it did detect the significant effect of annual precipitation. The simulation of the pattern in the species number of invasive alien based on Model II, as forecasted by the best fit equation (Figure 1b), does suggest increasing numbers of invasive plants everywhere in the Basque Country.

However, when the sources of uncertainty of the simulation are combined to compute a prediction interval (Figure 1a-c), a wider scenario is depicted. Placing confidence limits on the predicted estimates shows that an almost unchanged pattern in relation to the modern situation (Figure 1a) is as likely as a more severe pattern (Figure 1c).

Our analysis leads us to conclude that, as expected, plausible models should consider the presence of spatial autocorrelation and include uncertainties in subsequent simulations. Similarly, in order to improve the accuracy of simulations and hence their practical usefulness, we recommend the study of broader geographic areas.

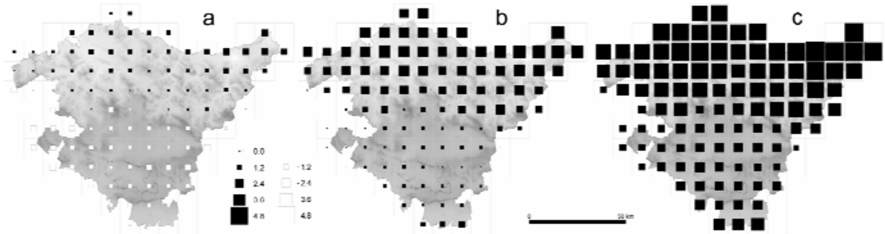

Figure 1. Simulation by Model II of the species number of invasive alien plants in the Basque Country under the IPCC scenario A1B. (b) Pattern forecasted by the best fit equation; this map represents the average behaviour of the RDA canonical axis modelling broad-scale spatial structures. (a) 95% prediction lower limit and (c) 95% prediction upper limit for the simulated pattern.

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Combining bioclimatic models with field trials to reduce uncertainty and aid management decisions on plant invasions in the face of climate change

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In the coming decades, climate change will lead to greater uncertainty for management decisions on invasive species. To date, climate change and plant invasions have each been studied extensively, but few studies have considered their combined and potentially synergistic impacts (Thuiller *et al*. 2007). Climate change, however, may provide opportunities for alien plants to expand into regions where they previously could not survive and reproduce, especially for species originating from warmer areas introduced into temperate areas (Walther *et al*. 2009). Bioclimatic models have become a popular – and often the only feasible - tool to provide a first insight to the threat invasive species may pose in the future. However, concerns have been raised as to the validity of such models when applied to novel climates or regions.

Consequently the models in this study (based on a maximum entropy algorithm) are trained in an approach that minimises extrapolation and are applied to a range of climate change scenarios, using three newly naturalised plants in New Zealand from warmer native ranges as a model system (*Archontophoenix cunninghamiana*, *Psidium guajava* and *Schefflera actinophylla*).

To validate the models we conducted field trials to test whether the alien plants perform as expected in suitable, potentially suitable and unsuitable habitats (as identified by the models): seedlings are grown in six sites across the country and their performance is measured in relation to the differing climates.

The results of the bioclimatic models show that the three species are likely to expand their range by the end of the century: depending on the climate scenario used, suitable habitat is predicted to increase by as much as 170% (*A. cunninghamiana*), 130% (*P. guajava*) and 210% (*S. actinophylla*) compared to the currently suitable habitat (Figure 1).

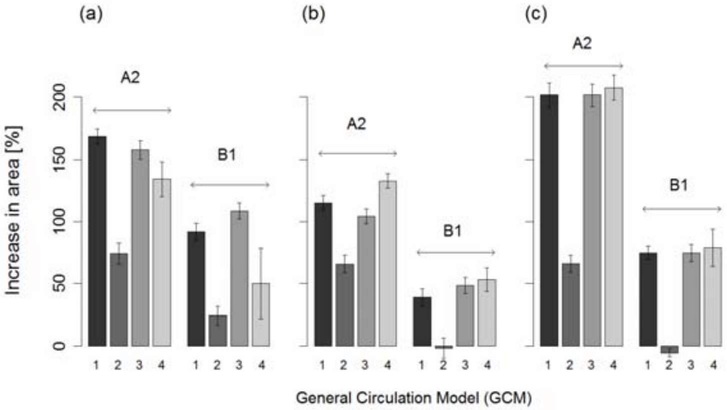

Figure 1. Mean increase in suitable area ± standard error (for ten cross validation models) in New Zealand by 2090 relative to current area, for emission scenarios A2 and B1 and four different GCMs: 1 CCCMA-CGCM3; 2 CSIRO-Mk3.0; 3 GFDL-CM2.0; 4 UKMO-HADCM3, for (a) *A. cunninghamiana*, (b) *P. guajava* and (c) *S. actinophylla*.

Preliminary results of the field trials indicate that the two sites identified as potentially suitable show as high if not higher growth rates (measured as height and number of leaves) than the suitable sites, where these plants have already naturalised. Therefore, the field trials suggest that the models have identified areas at risk from invasion. The combined results from both the models and field trials provide strong evidence of the potential invasiveness of these plants. By having higher confidence in the potential risk of newly naturalised plants and where they may spread, we can aid management decisions that lead to greater cost effectiveness: resources can be prioritised and allocated effectively, to control alien plants at a much earlier stage of their naturalisation.

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The contribution of seed release to population spread of an invasive thistle under climate change

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The ability of species to track suitable habitat under climate change is strongly predicated on dispersal. Thus, estimates of species movement as it would occur under future climatic conditions are likely to be an important component of models of future species distributions (Brooker *et al*. 2007). This may be especially true for passively dispersed species. As the maternal environment is affected by changes in climate, both the number of offspring dispersing and their propensity to disperse long distances are likely to be altered as well.

In studies of wind dispersed seeds, it is well known that dispersal kernels are strongly affected by maternal plant characteristics, such as seed release height and seed terminal velocity (Jongejans *et al*. 2008). Seed release characteristics, which initiate movement of seeds, can also affect the ultimate shape of the dispersal kernel (Soons & Bullock 2008), but are rarely studied. To quantify how seed release is affected by climate change, we experimentally manipulated temperature in a field study of the wind-dispersed invasive plant *Carduus nutans* (Asteraceae) and quantified proportions of seed released at different wind speeds in a wind tunnel. Subsequently, we examined the effect of the probability of seed release on the projected population spread rate (c*) (Neubert & Caswell 2000) under warmed conditions.

We found that experimental warming significantly increased the probability of seed release in wind tunnel trials by 7%. When these data were incorporated into existing matrix integrodifference equation models of population spread for this species, which already include increased maternal plant height (Zhang *et al*. 2011), warming was projected to increase the population spread rate of *C. nutans* by 31% per year due to increased temperature. Our results suggest that changes in nonrandom seed release, together with increased maternal plant height (Zhang *et al*. 2011), will be an important determinant of increased spread for this problem species under future climate scenarios. In general, our results suggest that models of future distributions of wind-dispersed species that do not include information about species' dispersal responses to climate will incur significant errors.

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Modeling the establishment potential of *Scaphoideus titanus*, vector of Grapevine Flavescence doree phytoplasma, in Europe by using the CLIMEX model

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The leafhopper *Scaphoideus titanus* (Homoptera: Cicadellidae) is the principal vector of Grapevine Flavescence dorée (GFD), the most severe grapevine diseases in Europe. *S. titanus* is a Nearctic species that has been accidentally introduced from North America into Europe (Bonfils & Schvester 1960). Since then, both the vector and the disease have spread significantly: in Austria, *S. titanus* has established in parts of Styria (Zeisner 2009); and FD was detected in 2009 (Reisenzein & Steffek 2011). Phytosanitary measures have been undertaken to eradicate this disease. The research project VitisCLIM was initiated to model the current and future potential distribution of FD and *S. titanus* in Europe and to define vine growing areas of high risk in Austria, amongst other objectives (Steffek *et al*. 2011).
The potential geographical distribution of *S. titanus* in Europe was modeled using the CLIMEX® modeling software (Sutherst & Maywald 1985). CLIMEX® calculates an index of climatic suitability, the ecoclimatic index (EI), based on species specific parameters. The EI indicates the overall suitability of a given location for the establishment of a specific species.
CLIMEX® parameters for *S. titanus* were inferred from its occurrence in North America, Europe and physiological data of *S. titanus* from scientific literature.
Distribution maps of *S. titanus* and FD were produced based on a literature review and were further used for comparison with the modeled CLIMEX® distribution. Finally, the vine growing regions in Europe were imported to a geographical information system to create composite risk maps with the EI values of the CLIMEX® model.
The CLIMEX® modeling of the present distribution of *S. titanus* in North America and Europe match the reported distribution pattern: regions where *S. titanus* is known to be very abundant (e.g. in the south of Central Europe and France) have a high EI value, whereas areas where its absence is confirmed provide no growth or very low EI values, indicating that survival of *S. titanus* is only transient.
By combining the output data of the CLIMEX® modeling for *S. titanus* distribution with the vine growing areas in Europa, it was possible to indicate areas not yet invaded, which would provide suitable climatic conditions for the establishment of *S. titanus*. Vine growing areas in the west of Germany, northeast of Austria, Hungary, Slovakia, south of Czech Republic, Rumania and Bulgaria have a high risk of invasion of the vector species in the future. The risk of vector establishment in vine growing areas in South-Europe is lower because of less favorable climate conditions there.
It is concluded that not climate but the distribution of the host plant *Vitis* spp. is the limiting factor for spread of the vector, as the land area climatically suitable for establishment of *S. titanus* extends over the vine-growing area in Europe.

Acknowledgements
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Acute cold winter temperature abnormalities and invasive species: an overlooked facet of global climate change?

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Successive cold winters during recent years have done little to convince climate change sceptics of the general warming of the Earth's atmosphere (see Whitmarsh 2011). Paradoxically, however, global warming is likely to be intricately linked to such cold winter extremes in parts of the Northern Hemisphere. Recent 'winter highs' in the Arctic, accompanied by anomalous losses of winter sea ice coverage in the Barents and Kala Seas, has been suggested to instigate cold winter temperature anomalies in Eurasia (Liu *et al*. 2012). The North Atlantic Oscillation index has also progressively become more and more negative in recent years, producing northerly surface wind anomalies which has led to an increase in southward advection of cold Arctic air in Northern latitudes (Wang *et al*. 2010). Whilst unlikely to halt the northward migration of both native and non-native species, the predicted increase in the frequency of acute climatic extremes, particularly cold winter snaps, may well play a major role in suppressing the rate of invasiveness of non-native species within their respective new environments (see Canning-Clode *et al*. 2011, Firth & Hawkins 2011). Using the intertidal, non-native Chilean oyster (*Ostrea chilensis* Philippi 1845) as a model species, the current study investigates the potential effects of lethal and non-lethal climate change-induced cold winter temperature stress on the future success of a non-native species within its introduced range. By exposing various size classes of oysters (small: 25-35mm, medium: 45-55mm, large: 65-75mm shell length) to a single, 2h period of freezing air temperatures (-2°C, -6°C or -10°C, thus mimicking conditions potentially experienced at mean low water spring tides), oyster survival rate was shown to be significantly lower with decreasing air temperature (Kaplan-Meier Survival Analysis: $X^2 = 91.706$, $p < 0.001$). Small oysters (i.e. those likely to be experiencing their first winter) cooled and thawed as much as three and nine times quicker than their larger counterparts respectively, and were also subjected to significantly greater periods of extracellular ice formation (see Table 1).

Table 1. Mean (±SE) change in internal temperature of small and large Chilean oysters (*Ostrea chilensis* Philippi 1845) exposed to an aerial temperature of either -6°C or -10°C for 120 minutes, immediately followed by a thawing period of submerssion in seawater held at 5°C. Comparissons between both size fractions within each temperature treatment: * = p<0.001, ** = p<0.05.

	-6°C		**-10°C**	
	Small	*Large*	*Small*	*Large*
Freezing rate (°C min^{-1})	0.122 ± 0.015*	0.040 ± 0.007*	0.256 ± 0.017*	0.092 ± 0.008*
Thawing rate (°C min^{-1})	1.331 ± 0.130*	0.144 ± 0.031*	0.443 ± 0.042*	0.227 ± 0.012*
Total time frozen (mins)	110.2 ± 1.8*	84.4 ± 4.6*	104.2 ± 2.0**	76.6 ± 8.7**

However, no significant difference was observed between oyster survival rates across size classes within each temperature treatment, suggesting that smaller, younger oysters are relatively more tolerant to freezing conditions than larger conspecifics ($X^2 \leq 2.00$, $p \geq 0.368$). Four weeks following a single 2h exposure period at -2°C, -6°C and -10°C, survival rates were 95%, 80% and 55% respectively. No oysters died in both control and procedural control treatments, confirming that the freezing air temperature, and not aerial exposure, was the only factor responsible for the decreasing survival rate. Such a pattern was mirrored during field surveys conducted pre- and post-winter of 2010-2011, suggesting that acute periods of extreme cold during future winters may act as a 'ratchet mechanism' that could significantly reduce the invasion rates of many non-native species in a changing climate. Our findings are discussed in relation to the successful proliferation of this non-indigenous species within a designated Special Area of Conservation and its role in modifying the native biodiversity.

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Alien species databases: a tool for users or a toy for database developers?

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As biological invasions are gaining increasing scientific and managerial attention, the number of web resources dedicated to non-indigenous species is rapidly growing. Most of them started from plain species listings and gradually developed into more sophisticated information tools. Currently there are more than 200 different alien species databases on-line, but many urgent managerial and research needs remain uncovered or requested information is distributed over several resources. For example, in many cases information on bioinvasion impacts remains too descriptive and uncertain, which makes it difficult to apply for the bioinvasion risk assessments and management tools prioritizing. Also, advanced search option implemented in some of the online databases, provides data filtering with several attributes in format not suitable for the basic data analysis and presentation. In order to develop an information system practical for users, there are several issues to be considered: the proper and easily manageable structure; sufficient data to be mined; the data quality control system; daily maintenance and regular update; interactivity and feedback option. Permanent interaction between a database developers (technical personal), data suppliers and users must be ensured within the system. The success of a database depends not only on technologies used, but on how they are applied by users and satisfy their demands. Currently, these issues have been practically applied during the development of a new integrated information system on biological invasions within a European 7th Framework Program project VECTORS (Vectors of Change in Oceans and Seas, Marine Life, Impact on Economic Sectors). The primary outcomes of the system are: clearly separated data blocks, multi-criteria search and data retrieving engine, the editorial board responsible for the data quality control, linkage with external services (e.g. Biological Invasion Impact / Biopollution Assessment System (BINPAS) (Narščius *et al*. 2012)) and databases.

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Towards an integrated information system on marine non-indigenous species of Europe and neighboring regions

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Management of biological invasions should be based on scientifically sound and timely updated information on non-indigenous species (NIS). The information should be freely accessible, useful for research and practical for decision makers. Data on aquatic introductions collected within several EU 6th Framework program projects (DAISIE, ALARM, IMPASSE, MARBEF), were verified, completed and used as background information to develop a new integrated information system on biological invasions within a European 7th Framework Program project VECTORS (Vectors of Change in Oceans and Seas, Marine Life, Impact on Economic Sectors). This system contains data on taxonomy, biological traits and native origin of non-indigenous and cryptogenic species introduced to the marine environment and adjacent waters of Europe and neighboring regions. Introduction records include information on time, pathways, vectors and environmental conditions in the introduction areas. The geographical division allows retrieving information hierarchically by: ocean, ocean region, Large Marine Ecosystem (LME) or LME sub-region. In addition, all coastal European and neighbouring countries are assigned to the relevant LMEs or LMEs sub-regions (e.g. western Mediterranean, Adriatic Sea, and eastern Mediterranean for the LME "Mediterranean Sea"). Such combination ("country + LME" or "country + LME sub-region") generates a list of country areas (country coasts) within a LME (or a LME sub-region). The system is flexible enough to accommodate data on even smaller geographical divisions, such as ports, marine protected areas, etc. An important component of the system is a bioinvasion impact assessment tool (BINPAS) allowing estimation of the bio-pollution index, based on the abundance and distribution range of a NIS and the magnitude of its impacts on native communities, habitats and ecosystem functioning (Olenin *et al*. 2007). The bio-pollution index is used for an initial assessment of sea regions under the European Marine Strategy Framework Directive (MSFD). Another innovation is an information block on the impacts of invasive NIS on the environmental quality parameters used in the EU Water Framework Directive: biological communities, physico-chemical conditions and hydro-morphological patterns. The main challenge developing an information system is to ensure the consistent flow of accurate and reliable information on the distribution of NIS distribution their impacts supported by regional experts network.

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Aquatic invasive species and biotic indices: a fake evidence of water quality improvement?

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Human impacts in aquatic ecosystems are being addressed by legislation to protect and restore offshore, coastal, transitional and fresh waters. In Europe, the key directives related to biodiversity of aquatic systems, the Habitat Directive (92/43/EEC), the Water Framework Directive (WFD (2006/60/EC) and the European Marine Strategy Framework Directive (MSFD 2008/56/EC) are aimed at improvement of aquatic environment and preventing biodiversity loss. The implementation of the Directives includes initial status assessment of the water bodies using different types of parameters, so that measures to restore or maintain ecological status can be effectively targeted. This requires development of the cost effective monitoring tools and establishment of various metrics that allow detecting and classifying the human induced changes and determination of ecological status.

The range of biotic indices considered for the ecological status assessments includes the Azti-Marine Biotic Index (AMBI (Borja *et al*. 2000)), the Benthic Index of Biotic Integrity (B-IBI (Weisberg *et al*. 1997)), the Benthic Opportunistic Polychaetes and Amphipods Index (BOPA (Dauvin and Ruellet, 2007)), the Benthic Quality Index (BQI (Rosenberg *et al*. 2004)), the Infaunal Trophic Index (ITI (Mearns and Word, 1982)), the Multivariate AMBI (M-AMBI (Muxika *et al*. 2007)) and the Infaunal Quality Index (IQI (Borja *et al*. 2007)). However, most indices have been created for the benthic subtidal habitats in true marine environments and therefore may not be entirely applicable to the naturally stressed low-diversity brackish water ecosystems. Although relations between salinity effects and various biotic indices have been addressed (e.g. Zettler *et al*. 2007) and possible modifications suggested (Fleisher & Zettler 2009), other external disturbances have been little discussed.

In this study we test how the occurrence of non-indigenous benthic species in the macrofaunal assemblages may affect the ecological status assessment and bias the values of BQI. We analyse two invasive species – the epifaunal zebra mussel *Dreissena polymorpha* and infaunal polychaete *Marenzelleria neglecta* in the brackish water Curonian Lagoon (SE Baltic Sea). Both species are locally dominant and affect the distribution of other benthic organisms. They form local patches of relatively high structural and biological diversity in the benthic environment, therefore their introduction may indicate false environmental quality improvement if reflected by species richness based indices.

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Planting European sentinel trees in Asia, an early warning method for the identification of forest insects potentially invasive to Europe

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The major part of the exotic insect species which have recently established in Europe are of Asian origin (Roques *et al*. 2010). This is especially verified for the species related to woody plants (Roques 2010). Most of these invaders have never been intercepted by the European quarantine services (Kenis *et al*. 2007). In order to identify the Asian pest species that could potentially affect European trees in the near future, two sentinel plantations were established in China and their their colonization was surveyed from summer 2008 to autumn 2011 in the course of the EU- funded projects ALARM, PRATIQUE and ISEFOR. The plantations were located in a suburban nursery area near Beijing and in a mixed conifer- broadleaved forest near Hangzhou (Southeastern China). The sentinel trees included five broadleaved species (*Quercus petreae, Q. suber, Q. ilex*, *Fagus sylvatica*, and *Carpinus betulae*) and two conifers (*Abies alba* and *Cupressus semprevirens*), with 50 to 100 1m-tall seedlings planted in randomized design per species. During this 4-years survey, 99 insect species were observed to be capable of switching onto these newly offered hosts, especially in the plot surrounded by a forested environment. Among these insects, a total of 34 species showed more than 5 colonization events, essentially infesting *Q. petreae*, but also at a lower extent *Q. suber* and *Carpinus betulae*. The species included highly damaging defoliating insects such as leaf beetles, sawflies, weevils, and lepidopteran larvae, but also root- feeding grubs in the genus *Holotrichia* (Scarabaeidae). Most species appeared to be polyphagous and unexpectedly originated from the nearby cultivated crops more than from the surrounding forest trees. A key problem concerned species identification. More than half of the specimens, especially larvae, could not be identified at species level using morphological keys. Therefore, all the collected morphotypes were systematically sequenced for the Cox1 barcode gene and a nuclear gene, allowing both a few more specific identifications and the development of a sequence bank for quarantine purposes. The next step is to check the potential of all of these species to survive transportation to Europe, and then confirm their impact under quarantine conditions. A first species, a psychid moth, confirmed to be a potential threat for European broadleaved trees.

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Assessing the likelihood of introduction of forest pests based on their worldwide occurrence

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The trade in woody plants for planting (WP4P) is a major pathway for the introduction of alien forest pests and diseases into Europe. Phytosanitary inspections at the import are essential to prevent such introductions, but the inspections are limited and target recognised pests, their hosts and shipments that are likely to contain them. In addition, the selection of inspected shipments, and thus the likelihood of interception of alien forest species, depends on expert judgement. We made an objective assessment of the likelihood of introduction of individual species and a prediction of potential sources of invasive species based on worldwide distribution of known pests.
We analysed distribution data for 1009 invertebrate pests and pathogens of woody hosts in 351 regions: 183 countries, plus seven large countries that were subdivided into regions. Countries and regions with similar pest species assemblages were identified for each of the organism group using hierarchical cluster analysis and the likelihood of introduction of those species was calculated as the fraction of countries within the cluster containing EU and EFTA countries where the species is present. Most pest species in the database are already present in one or more EU countries, which indicates that the introduction of these species into a EU country primarily occurs through spread within the EU. The non-EU regions with the most similar pest species assemblages are North America, the Mediterranean region, the northern part of Eurasia and Australia/New Zealand, which have a broadly similar climatic range as the EU. Combining the results of this analysis with economic data provides indications about the likely origin of unidentified, future alien species establishing in Europe, which should be considered when assessing the likelihood of introduction of species through import of WP4P.

Development of a classification model based on field spectral and biochemical leaf properties to analyse Acacia invasion via remote sensing

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Acacia longifolia (Andrews) Willd., a tall shrub from Southeast Australia, is an invasive species in many countries worldwide. In Portuguese dune ecosystems, it has a profound impact on biodiversity and ecosystem function, but most of the studies are limited to plot or stand scale (see Rascher *et al*. 2011a, b, 2012). It is a very promising approach to apply state-of-the-art hyperspectral and LiDAR remote sensing to analyse the impact and upscale the results from stand to ecosystem scale. As baseline information, a robust classification model based on field spectral data and biochemical leaf properties is necessary. In order to distinguish *A. longifolia* from other invasive and native species, leaf reflectance spectra (350-2500nm) and tannin concentration were used to develop a robust classification model. In the field, an ASD FieldSpec FR Spectroradiometer attached to an ASD single leaf clip assembly allowed to collect 750 in-situ leaf reflectance spectra of seven characteristic dune species (*Acacia cyanophylla* (L.), *Corema album* (L.) D. Don, *Halimium halimifolium* (L.) Willk, *Juniperus phoenicea* subsp. *turbinata* (Guss.), *Pistacia lentiscus* (L.) and *Pinus pinea* (L.)) at three sites in an area of study of ca. 15km² in SW Portugal. Additionally, leaves of the spectrally measured species were sampled and analysed for tannin concentration. Partial least square (PLS) regression was used to link the obtained leaf reflectance spectra of *A. longifolia* to their corresponding tannin concentration. Five wavelength regions (675-710nm, 1060-1170nm, 1360-1450nm, 1630-1740nm and 1840-1920nm) being highly correlated with tannins, were identified. Then, a spectral-based classification model of the different plant species was performed using linear discriminant analysis (LDA) combined with principal component analysis (PCA). For the prediction 35 bands in the UV / VIS range (675-710nm) are sufficient to achieve a prediction accuracy of 92% for *Acacia longifolia* and 89% for non *Acacia longifolia*. In comparison, selecting the entire wavelength range, only 85% of *Acacia longifolia* were correctly predicted. This classification model will be applied on canopy and ecosystem scale using airborne high-resolution hyperspectral remote sensing data. We will also implement more biochemical leaf properties such as carbon, nitrogen, and chlorophyll for further classification and interpretation of our data.

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Remote sensing in invasive plant ecology? Detection, monitoring and control of alien herb species

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Plant invasions represent a serious treat in our changing landscape. Techniques enabling fast and precise monitoring and providing information on spatial structure of invasion are needed for efficient protective strategies to be implemented. Remote sensing (RS) provides a useful tool successfully applied in studies of shrub and tree invasions however rarely focusing on herbs. Such application is possible only if the data provide enough spectral and/or spatial detail, the species is distinct from surrounding species and background, forms dense and uniform stands, or is large enough to be detected.

Our study examines detection of two invasive herbs - giant hogweed (*Heracleum mantegazzianum*) in Czech Republic and Japanese knotweed (*Fallopia japonica*) in Slovenia. Giant hogweed is the largest central European forb (4-5 m tall) with large distinct white inflorescences (diameter up to 1 m), often forming large uniform stands. The latter is also typical of Japanese knotweed that is, listed by the World Conservation Union as one of the world's 100 worst invasive species.

The data of different spectral and spatial resolution, such as panchromatic, color and infrared aerial photography (cca 0.5 m resolution), and satellite data (Rapid Eye, 5 m; and WorldView-2, 0.5 m) were tested using pixel-based, object-based (OBIA), and hybrid approaches. Computer assisted classification of very high resolution (VHR) data (especially that of low spectral resolution) brings difficulties. OBIA methods incorporating both the spectral and spatial information augmented classification accuracy compared to the traditional pixel-based methods. In OBIA, the image is segmented into objects that are then classified according to spectral variables, shape, texture, size, thematic data, and spatial relationship.

Giant hogweed distinct appearance enabled its detection from VHR imagery (even on low quality historical data). Rule-based hierarchical OBIA classification using rules related to spectrum, shape, texture, and context achieved comparable high accuracy. On the medium resolution satellite imagery only larger homogeneous stands could be recognized. Since the spectral information was crucial, pixel-based methods (supervised classification, Maximum Likelihood) were the most successful. Since the species is best detected in flowering, the success of classification depended on the time of the data acquisition. Hybrid approach combining pixel and object based classification was applied to Japanese knotweed classification using VHR data. Image segmentation was followed by spectral and spatial sub-object (pixel- and object-based) analysis using the Kolmogorov-Smirnov test. The sub-object spectral and structural analyses (mainly measure of object fragmentation, i. e. heterogeneity of canopy architecture) were incorporated into a classification scheme. Proposed approach enabled detection of different stages of knotweed growth and differentiation from similar blackberry and other species, considerably improving the accuracy.

Our study established comparably accurate detection methods of two noxious invasive species. Once fully established, both invaders grow rapidly, outcompete native species and their removal and elimination is difficult. Early detection enabled by RS means would make management measures more efficient and less expensive. We consider described methodology applicable over larger areas to map the onset and progress of invasion, identify areas at highest invasion risk and choose the appropriate control management.

Nature Locator: Geospatial Smartphone Apps and the use of Crowd Sourcing for the Accurate Recording of Invasive Species

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Obtaining accurate data about the distribution of invasive species is of paramount importance when it comes to assessing impact and formulating an appropriate response. But data provision is often patchy and records are usually unverifiable and lacking accurate geographic reference. The University of Bristol's Nature Locator team has addressed these problems by combining the development of case specific smartphone applications with the power of crowd-sourcing data collection. The smartphone apps enable real data to be collected by non-scientists in the field. Critically, each record collected is verifiable since it is comprised of a photograph, along with other relevant metadata. Records are also accurately geo-located since the apps utilise the phone's GPS capabilities.

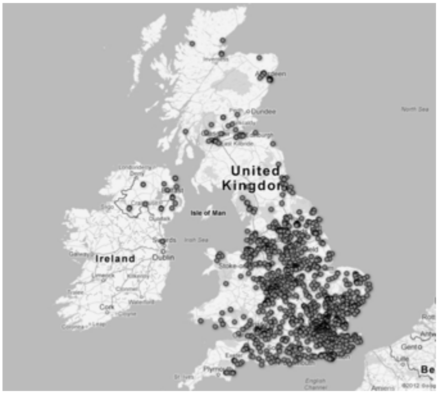

Figure 1. UK map showing distribution of records for *Cameraria ohridella* collected by the Leaf Watch app

The Nature Locator team's inaugural project "Conker Tree Science: Leaf Watch" (http://leafwatch.naturelocator.org/) took forward a project which had used web-based forms for data collection in 2 previous years. The development of an app was a large factor in successfully engaging the public and generating records. The app was principally used to provide more information on the UK distribution of the invasive horse-chestnut leaf miner moth (*Cameraria ohridella*). 5500 records were collected from all over the UK in the four month recording period. The project also explored the validation of submitted records using crowd sourced effort in order to further increase public engagement and reduce the burden on project scientists.

Such an approach to data collection and validation led to the following outcomes:

- » Greatly enhanced accuracy of records over previous years' owing to photographic evidence and GPS based geo-location
- » A tenfold increase in records collected compared with previous years
- » Geographic coverage which spanned the entire UK enabling scientists to get a clearer picture of the distribution of *Cameraria ohridella* (see Figure 1).
- » Large-scale public engagement
- » Widespread media interest and publicity
- » Increased public awareness of the environmental issues in hand

The Nature Locator team has designed and released a second app called PlantTracker (http://planttracker.naturelocator.org/). This project will enable both the public and staff at the Environment Agency (http://www.environment-agency.gov.uk/) to locate incidences of three priority invasive plant species: Japanese Knotweed, Himalayan Balsam and Floating Pennywort in order to facilitate treatment and monitoring. Data from this project will be available by September 2012.

Creation and role of the Observatory of ragweed in France

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Ambrosia artemisiifolia L. (common ragweed) was accidentally introduced into France in the 1860s. with red clover seeds (Chauvel *et al*. 2006). The species was later introduced in many places and at different times. A number of different factors (cropping system evolution, climate change, etc.) contribute to increasing the distribution area of this allergenic species in France.The invasion of the French territory by common ragweed has turned into a real issue in terms of public health (Laaidi *et al*. 2003) and agricultural impacts (Chauvel *et al*. 2010). The Ministry for Health and the National Institute for Agronomic Research have set up in June, 2011 the *Observatoire de l'ambroisie* (the Observatory of ragweed). With the objective of becoming a center of references on ragweed, the Observatory will contribute to value the knowledge on the plant, in particular its effects on human health, on the sustainable actions of prevention, as well as on the scientific data and the projects of current research. The activities of the Observatory are intended for the people at large, for the associations, for the various concerned ministries, the regional Councils, professionals of healthcare and the agriculture sector as well as to the person in charge with the different habitats where the species is present. The Observatory is in charge with encouraging actions from the local actors and bringing coordination for different ragweed control operations. Various actions have already been undertaken: (i) formation of ragweed advisors within the framework of the National Environment and Health Plan (ii) setting-up of experiments to quantify the cost of a sustainable management at various spatial scales, (iii) organization of the Ambrosia 2012 symposium (iv) information about International Ragweed Day (v) updating of the website: http://ambroisie.info,. The objective of the Observatory is to support the local actions, to communicate and to broadcast the methods showing an effective control of this invasive species. The Observatory will soon lay the emphasis on the new comer giant ragweed.

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Prioritisation of alien plant species in Poland: the basis for management

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Assumptions about nature conservation made in Poland, based on valid legal documents, are aimed at limiting the establishment and spread of new alien species posing a threat to native biodiversity. Effective management of alien species requires their appropriate categorization. Also the introduction of the *EU Strategy on Invasive Alien Species* will require the compilation of a series of lists of alien plants according to their influence on the environment, the economy or health.
Current and verified lists of alien plant species in Poland (*Alien plants in Poland with particular reference to invasive species*) will be published by The General Directorate for Environmental Protection (GDEP). 'New' catalogues of alien plant species for Poland include: a verified and updated list of naturalised alien plants, a verified and updated list of casual alien plants, cultivated trees and shrubs most often escaping from cultivation and, in particular, a list of invasive alien plant species.
Criteria for identifying the status of species were adopted after being drawn by an EPPO team of experts (Brunel *et al*. 2010) and were considered together with studies undertaken by the present authors concerning: i) the distribution range in Poland based on the number of localities (of ATPOL squares – Zajac & Zajac 2001) and distribution maps; ii) the size of the local populations; iii) the type of habitats colonized; iv) dynamic tendencies; v) type of threat.
From the list of alien species in Poland a group of invasive species was identified. Based on the criteria adopted, they were allocated to one of the following groups of species: i) invasive at the national scale, ii) invasive at the regional scale, iii) invasive locally, and iv) potentially invasive. Furthermore, natural habitats threatened with penetrating of the given alien species have been identified.
At the national scale, 35 species were included in the group of invasive species, including 12 weeds of cultivation; 23 invasive in particular regions (including 4 weeds); 14 locally invasive and 16 potentially invasive.

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Management of invasive plants on a regional scale in Saxony-Anhalt, Germany

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Since 2010 the Coordination Centre Invasive Plants in protected areas of Saxony-Anhalt – KORINA – is working in Halle/Saale, Germany. Until then information about alien invasive plants was difficult to access and stakeholders were not well connected. The Coordination Centre is part of the project "Early warning system and planning of measures against invasive plant species in protected areas of Saxony-Anhalt".
KORINA aims to prevent invasions of alien invasive plants, to establish an early warning system and to enhance control and renaturation. The main tasks of its staff are to create, collect, store, process, evaluate and distribute information about alien plants in Saxony-Anhalt (see Table 1).

Table 1.Main tasks, results and *plans* of KORINA (Coordination Centre Invasive Plants in protected areas of Saxony-Anhalt at UfU)

<table>
<tr><th>KORINA</th><th>Prevention</th><th>Early warning system</th><th>Control and renaturalisation</th></tr>
<tr><td rowspan="2">Public relations work</td><td colspan="3">• information about the risks of introducing and spreading invasive species in newspapers, presentations and field trips</td></tr>
<tr><td>• teaching material for schools</td><td>• appeal to join in the survey</td><td>• promotion of measures to control invasive alien plants</td></tr>
<tr><td rowspan="2">Networking</td><td colspan="3">• network of stakeholders and experts in Saxony-Anhalt, Germany and Europe
• survey of stakeholders in Saxony-Anhalt
• map of management actions in Saxony-Anhalt</td></tr>
<tr><td></td><td>• rapid information about new incursions of alien species, rapid assessment and measures</td><td>• coordination of measures against Heracleum mantegazzianum, Fallopia spec., Lysichiton americanum</td></tr>
<tr><td rowspan="2">Information management (www.korina.info)</td><td colspan="3">• web-based database "Alien plants in protected areas in Saxony-Anhalt" with currently 47000 datasets, where new data can be added via internet
• smartphone app for data collection
• specific information about selected invasive species based on internal bibliographic database</td></tr>
<tr><td></td><td>• rapid information about new incursions of alien species can be distributed via the web-based database</td><td>• information about effective measures;
• consulting service for stakeholders</td></tr>
</table>

<table>
<tr><td>Monitoring</td><td colspan="3">survey of Campylopus introflexus; investigation of alien invasive plants along the rivers Kalte Bode/Harz and Mulde; mapping of Acer negundo along the river Saale; survey of Prunus serotina in Oranienbaumer Heide
control of success of measures
network of volunteer botanists</td></tr>
<tr><td>Measures</td><td>black list of invasive alien plants in Saxony-Anhalt</td><td>implementation of rapid measures or rapid coordination of measures</td><td>control of Lysichiton americanum, management of Heracleum mantegazzianum along rivers
project “River Selke without invasive alien plants”
Analysis of the impact of selected potentially invasive plants</td></tr>
</table>

With this information stakeholders can work to control invasion processes of plants and the cooperation between administrations, experts and nature conservation organisations is increased. Furthermore, KORINA gives information about funding of control measures to stakeholders.
During the first part of the project a bibliographic database and the website with a web-based plant database and an online mapping system were generated (www.korina.info). In the second part, the focus is laid on evaluation of alien plants by developing a black list of alien plants and by analysing supposed negative effects of selected plants on biodiversity.

Spread of *Campylopus introflexus* (Hedw.) Brid. in protected areas on sandstone soils in Saxony-Anhalt, Germany

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In 2011 a survey of the current distribution of *Campylopus introflexus*, an invasive species of moss, in selected protected areas north of the Harz Mountains was conducted. *Campylopus introflexus* was found in this area since the 1990ies. The survey showed that some of the protected areas are already invaded in most of the suitable habitats, whereas in other areas the invasion of *Campylopus introflexus* seems just to start. The results of the survey are available and constantly updated in the web-based database found on www.korina.info.
Campylopus introflexus is found on stabilised bare sandy soils in *Corynephorus canescens* grasslands and *Calluna heathlands* and their adjacent birch or pine stands. In some areas *Campylopus introflexus* is occupying all bare soils between grasses or heath-plants. The agencies for nature conservation and KORINA are now looking for methods to mitigate the impact of the moss on fauna and flora. Some experiments will be conducted in 2012 and 2013.
KORINA is part of the project "Early warning system and planning of measures against invasive plant species in protected areas of Saxony-Anhalt".

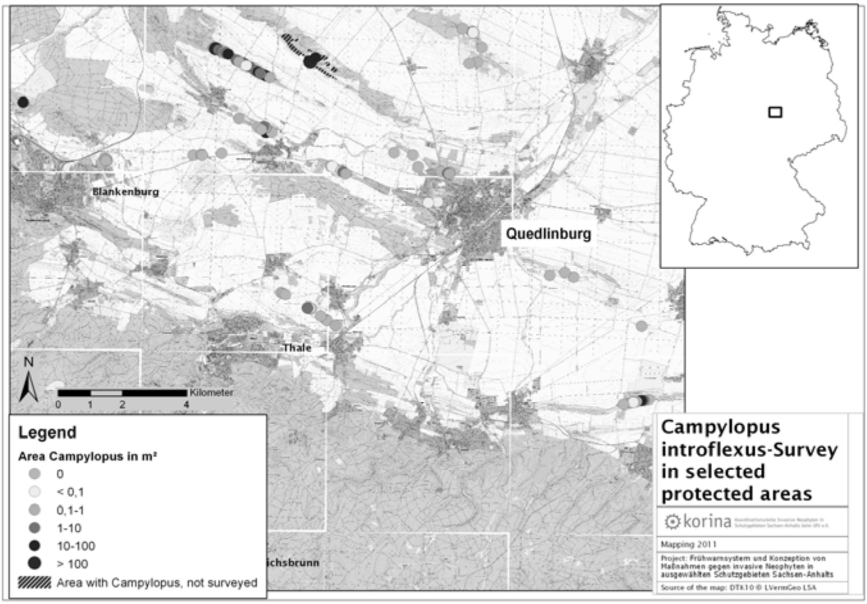

Figure 1. Distribution of *Campylopus introflexus* in selected areas north of the Harz Mountains in Saxony-Anhalt (Germany).

Works and projects of the French Working Group «Biological Invasions in Aquatic Environments» (WG BIAE): studies on aquatic species management and realization of a good practice guide

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The presence of invasive species often comes along with negative impacts on the environment and on human activities and health. That can also have significant economic consequences (Pimentel *et al.* 2005, Kettunen *et al.* 2008).

For these reasons, a French Working Group «Biological Invasions in Aquatic Environments» was instituted in 2009, under the coordination of the French National Agency for Water and Aquatic Environments (ONEMA) and the National Research Institute of Science and Technology for Environment and Agriculture (IRSTEA). Bringing together managers, institutional investors and researchers, the main objective of the WG BIAE are generate a set of guidelines for the management of biological invasions in aquatics environments and develop operational tools of species management intended for managers and policy makers.

The management representatives insisted on the needs and expectations of local managers, including providing recommendations for practical interventions. As a consequence of these comments, a survey on invasive alien species in aquatic environments and their management was initiated. The final objective of this survey is to produce a synthesis of the management interventions of invasive aquatic species (IAS) in France.

In addition, a balance sheet of available knowledge on existing management interventions on IAS in aquatic environments in France should take form as a guide of "good practices". Providing a clear basis for reflection and a reasoned approach for managers to aid the implementation of management actions, this guide should take into account the specificities of each situation, including the characteristics of the site itself, alien species being managed or whose management is desired, and human needs expressed. Its realization is planned in two parts: the first will include general information and in the second, a collection of examples of management actions should be detailed as precisely as possible.

An other project of the WGBIAE is to analyze available information on a "case of management" especially in terms of efficacy, failure or success, to extract the ecological, ethnological, economic and institutional aspects in order to generalize to other sites and fuel the debate on comprehensive approaches on IAS management already implemented in France.

The choice of case was focused on the management of water primrose in the Regional Natural Park of Brière (West of France) for which all necessary information is already available or relatively easy to obtain and where it will be possible to identify and quantify the impacts this biological invasions.

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Invasive riverside plants on peninsular Spain: who are you and where do you come from?

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Mediterranean Basin is one of the main biodiversity hotspots in the world and has high sensitivity to biological invasions (Gritti *et al*. 2006). Among different habitats, inland wet areas are shown to be between the most invaded environments of the Mediterranean Basin, with around 20% of alien species (Arianoutsou *et al*. 2010). Riversides are one of the inland wet habitats that form continuous linear systems along large tracts of land, acting as biological corridors and presenting high border to surface ratios, thus being strongly affected by neighboring vegetation and also more susceptible to be invaded by species of non-river ecosystems. In this study we conducted a first approximation to the exotic flora of woody riverside ecosystems from the mainland Spain.
We used data from a systematic sampling of all Spanish river basins. This data set was originally designed to characterize the conservation status of Spanish riparian vegetation and comprises 1088 relevès taken between 2001 and 2007 (Lara *et al*. 2004, Garilleti *et al.* in press). This is the first database including the whole continental Spain, thus providing a clear picture of invasive species in an ecosystem for a large climatic gradient within different biogeographic regions.
We characterized the total proportion of alien flora present in riversides considering their origin regions, invasive status and introduction way, as well as their life form, life cycle and habitat preferences. We also detected the most widespread alien plants for the studied territory.

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Human project impacts on vegetation: coping with alien plants

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The implementation of different types of infrastructures in natural areas has many times contributed to the dispersal and proliferation of alien plants species, triggered by construction and deforestation.
Although the spreading of alien flora is one of the major impacts affecting flora and vegetation, many times during the Environmental Impact Assessment (EIA) process it is commonly considered to be a minor problem and sometimes little work is done to minimize or prevent this impact. Some of these impacts can actually implicate the lost of biodiversity in a large scale, especially taking to account the effects that invasive flora can have over the native vegetation.
The spreading of alien plant species is a problem that can and should be minimized, since early stages of EIA process, whit a careful planning of construction actions and pos-construction control methodologies. The work should begin before construction, allowing to know which species are present in the project area, since different species require different mitigation and control measures.
The information gathered during EIA will allow the definition of specific mitigation measures to contain invaders spread during project construction, although the complete avoidance of this impact is very unlikely to be achieved. One example of a mitigation measure is the correct elimination of alien plant debris, which is especially important in cases of species that can resprout easily from vegetative reproduction. Most of the work regarding the control of invasive plant species is mainly done in post-construction, with the implementation of monitoring studies that will lead to control actions, if necessary. The planning of monitoring studies and possible control actions should start in the project pre-construction, taking in account the different problematic species. As so, if invasive plants are detected during monitoring plans, control measures can be quickly implemented, preventing the enlargement of the problem. This work should be as comprehensive as possible, taking into account that the control of these species is a lengthy and time consuming task, since it is often impossible to eradicate completely the problem.

Raccoon Tracks Identification Guide: Applying Animal Tracking Skills to Detect Invasive Exotic Species

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The raccoon (*Procyon lotor*) is listed as invasive exotic species (Official State Gazette No. 298 of 12 December 2011). Introduced through pet trade, the raccoon constitutes a potential threat to native biodiversity and human health (Beltrán-Beck *et al*. 2012). The species has already been established in the centre of the Iberian Peninsula and some individuals have been sighted in other regions, including the Balearic and Canary Islands (García *et al*. 2011). Pet owners release the animal into the wild when it grows up and becomes aggressive and annoying. Although the sale of raccoons is now prohibited, some people still keep the animal at home.

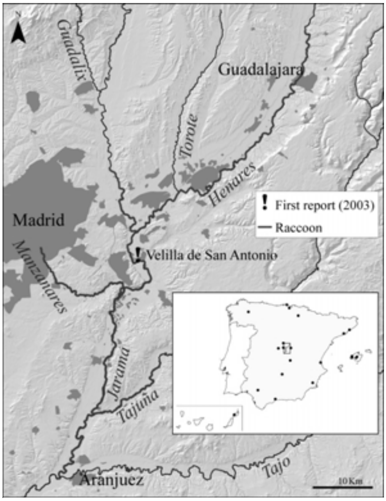

Figure 1. Distribution of *Procyon lotor* in Spain

Royal Decree 1628/2011, of 14 November, regulating the Spanish list and catalogue of invasive alien species, establishes the set up of an early warning system for detecting and monitoring non-indigenous potential invasive species. The eradication is only possible in the early stages of invasion.

Direct observation of carnivores, elusives and actives at night, is rare. Tracking is an economical and effective detection method (Virgós 2001). It doesn´t require equipment (scent station, track-plate or camera trap), only training (Jeffress *et al*. 2011).

Raccoon detectability is high, even at low density of individuals. The raccoon lives in riversides close to urban areas (escaped from or released into the wild by pet owners) and footprints are well-defined in wet terrain —raccoons are heavy animals. In addition, raccoons deposit and accumulate the scats in prominent sites, and don´t hide the remains of preys. The footprint is unmistakable, only in adverse substrates —dry terrain, coarse sand—, because of erosion —wind, rain— or inexperience of the observer might be confused with those of otter (*Lutra lutra*), badger (*Meles meles*), or coatí (*Nasua nasua*), introduced in Mallorca Island too. Scats can be easily confused with those of mustelids, fox (*Vulpes vulpes*), dog (*Canis familiaris*) or cat (*Felis* sp.).

Obtaining information about the current raccoon distribution and new introduction events would help to plan control and eradication actions, before raccoon population growth and range expansion affect native ecosystems. Early detection and rapid response system must be activated and citizen participation promoted.

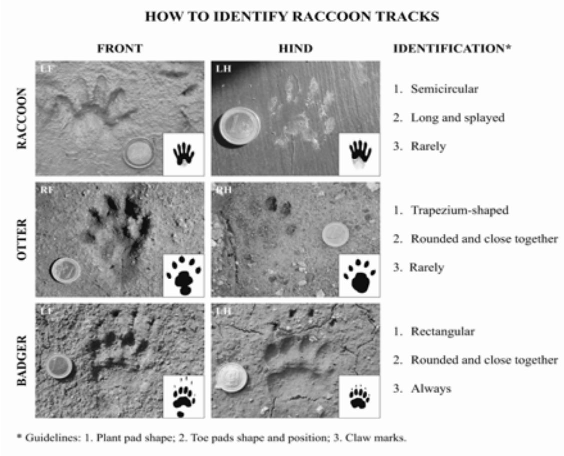

Figure 2. How to identify raccon tracks

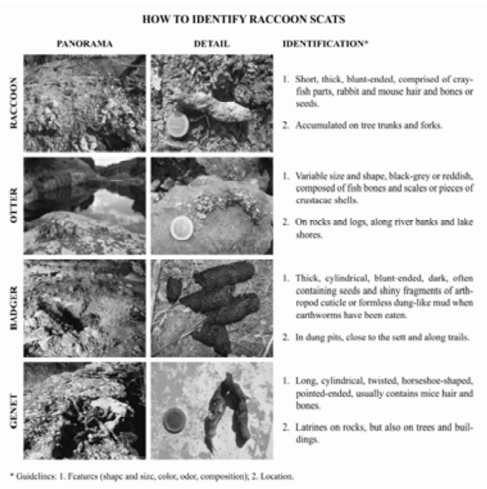

Figure 3. How to identify raccon scats

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Preventing plant invasions with the horticultural sector: first results of the Code of conduct on invasive plants in Belgium

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Ornamental horticulture is a renowned tradition in Belgium and in Europe, producing high quality plants for gardening and landscape plantings. However, it is also recognized as one of the main introduction pathways of invasive plants (Burt *et al*. 2007). Invasion success is facilitated by multiple secondary introductions through plantation and cultivation (Kowarik 2003). Despite the growing number of studies that highlight the environmental, economic and public health hazards caused by plant invasions, they remain less known outside the scientific audience. Due to the lack of information, horticulture professionals and gardeners still distribute and plant invasive species. In Belgium surveys revealed that 70-90% of invasive plants are still available within the horticultural market (Halford *et al*. 2011, Vanderhoeven *et al*. 2011). It is therefore necessary to communicate with ornamental plant users or producers to change attitudes, reduce the frequency of secondary releases and curb invasion rates. A European LIFE+ Information & Communication project entitled "AlterIAS" (ALTERnative to Invasive Alien Species) has been initiated in 2010 in order to deal with this issue.

A Code of conduct on invasive plants in Belgium has been prepared in the framework of this project, following the recommendations of the European strategy on IAS adopted by the Bern Convention. The code has been elaborated through a series of round table discussions involving scientists, representatives of administrations responsible for environment and main horticultural federations/associations. Two target groups were consulted amongst the latter, i.e. ornamental plant producers and sellers (nurseries and garden centers) and ornamental plant users (public green managers, landscape architects, garden contractors and representatives of botanical gardens). The specific measures listed in the code are the result of a trade-off between the environmental risk of plant species and their socio-economic importance related to ornamental uses. Five measures were unanimously approved: (1) know the list of invasive plants in Belgium; (2) stop the production and the plantation of some invasive plants; (3) disseminate information on invasive plants; (4) promote the use of non invasive alternative plants and (5) participate in early detection of new invaders.

Discussions were based on the list of 57 invasive plants available in the *Harmonia* information system (Branquart *et al*. 2010). A ban on the production and use of 28 species out of this list has been negotiated with the sector. It has to be noted that invasive plants at the very beginning of the invasion process or invading only very specific habitats were hardly perceived as detrimental by horticulture professionals, especially when they have a high economic and esthetic value. Recommendations on plantings have however been proposed in order to limit their use near protected habitats.

The code of conduct has been launched in September 2011. Most horticultural federations/associations have adopted it. An awareness campaign entitled "Plant different" is on progress to promote the Code amongst professionals. This participative approach is attracting new partners over time. At the end of 2013, 20% of professionals gathered in organizations and 60% of public green managers should have endorsed the Code.

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Tackling invasives through valuing and volunteering – a 2-pronged approach

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Addressing ecological issues requires a variety of approaches that can move from factual evidence to widespread action and invasive non-native species (INNS) are no different. This presentation will report on two linked approaches that are being pioneered in Cornwall and are based on an INNS national strategy (Defra 2008) and cost inventory (Williams *et al*. 2010).

Valuing Nature. The first approach used an image-based questionnaire to assess public perception of the monetary value of seeing wildlife on the Camel Trail - a disused railway line used by over ½ million people per year, who potentially experience similar wildlife due to its corridor nature. The questionnaire asked the respondent to indicate the effect on their Camel Trail experience of seeing a species, or knowing that the species was present even if it wasn't seen. Each person was asked to indicate a monetary value for 8 species on a scale beside each species' image. Four of the species were then identified as INNS with adverse impacts on native species (the estimated annual cost (from Williams et al 2010) was shown below each image). Respondents were asked to indicate a new value from the same range of values. All wildlife had a positive effect on the Camel Trail experience, ranging from £0.06 - £0.12. However, after the INNS were identified, people significantly[1] devalued their effect on the Camel Trail experience, with average values becoming negative and changes in valuation of -£0.09 to -£0.12p (Table 1). Thus, invasive species degrade the ability of the public to enjoy the biodiversity of the Camel Trail by approximately £50,000 per annum.

Student Invasive Non Native Action Group SINNG (www.sinng.org.uk) was set up by students at Cornwall College Newquay in 2010 as a Local Action Group to raise awareness and reduce the impact of INNS. Key actions include surveys, monitoring visits, removal, researching the effects on native wildlife and collaborations with other volunteer groups. With the leadership of a Project Coordinator funded by Defra, SINNG volunteers have focused on species offering the best chance of surveys identifying where action can be effective, while also providing opportunities for awareness raising, research and engagement with partners. SINNG volunteers have become involved with several schools, running activities based on their own designs of games and materials to increase awareness of INNS and their impacts. Workshops on biosecurity and identification underpin SINNG actions and help promote national "Be Plant Wise" and "Check, Clean, Dry" campaigns. Student volunteers have designed the SINNG logo, set up and manage social media and website.

These approaches offer the prospect of justifying action (by highlighting financial implications) and also engaging volunteers to achieve effective action. We are interested to make contact with groups who may wish to collaborate to apply these models more widely in Europe.

Table 1. Change in mean monetary value (pence) ± se (n=51) of 4 INNS species.

Rabbit	Canada goose	Rhododendron	Himalayan balsam
-9.0±1.1	-9.0±1.2	-12.0±1.1	-12.0±1.1

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[1] non-parametric repeated measures ANOVA, 3df, $p<<0.0001$

Public perception of non-native species and visions of nature in The Netherlands

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Public support is a major issue in non-native species management. However, not much is known about lay public perceptions of non-native species and their underlying values. Different views on nature and the human-nature relationship may result in different perceptions of non-native species risks and human intervention in nature (e.g. eradication measures). As a result, the public may not always understand or support measures aimed at control or abatement of non-native species. In this study, we measured the perception of nature and non-native species of the lay public in a survey administered in the Netherlands, also including variables such as level of knowledge about and support for control of non-native species. In general, respondents had little concern about non-native species in the Netherlands and did not express a specific positive or negative attitude towards them. However, most respondents were in favour of non-native species control in case of potential ecological or human health risks, indicating that harm is an important driver for public support. Prevailing views of the human-nature relationship and on balance in nature revealed that non-native species are perceived differently depending on whether respondents see themselves as stewards that have to protect nature and whether people feel that it is important to maintain a state of balance in nature. Finally, questions related to possible management options for different non-native species showed that control and eradication were predominantly opposed for species with a high cuddliness such mammals and bird species, while supported for insects and weeds.

The effect of newspaper coverage on stakeholders' prioritisation of invasive plants in Galicia

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Human behaviour 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 for agriculture, gardening, forestry, hunting, pet trade, etc. Therefore, the identification of those stakeholders' perceptions and attitudes to invasive species is essential for the effective implementation and support of public policies. Deciding how to allocate resources among potential strategies, and which species to control requires an understanding and support of the relevant social actors. Stakeholders' perceptions of the problem of invasive species are consequently of growing interest in the literature. Recent studies show that the perception of biological invasions issues is heterogeneous across stakeholders, invasive species, and local-social context (e.g. Bardsley & Edward-Jones 2007, García-Llorente *et al*. 2008, Vanderhoeven *et al*. 2011). A primary objective of this contribution is to identify stakeholders' perceptions of impacts and management of plant invaders in Galicia (NW Spain). We focus on the consistency/discrepancy among stakeholders involved in the risk and control measures that affect invader introduction and spread. The views of stakeholders that economically benefit from selling and using non-native plants are compared to those that are affected by their impacts and those that take control strategies. A secondary objective is to evaluate how natural and socio-economic variables determine stakeholders' preference ranking of the most important invasive plants. We use an exploted logit model to assess the importance of variables related to newspaper coverage and public control expenditures in the public perception of key plant invaders. Our results show that there is a greater social awareness and concern for certain species introduced for ornamental use and the forestry sector (*Acacia spp., Eucalyptus globulus, Carpobrotus edulis, Cortaderia selloana*). Our analysis provides evidence of the effect of the media on shaping the public's opinion of biological invaders. Stakeholders rank higher those invaders that appear more frequently and in extended newspaper articles. The level of public control investment does not have any influence on the ranking of most important species. Our findings provide support to the idea of reaching a social consensus in policy making, as stakeholder groups show non-significantly different attitudes to different management measures, welcoming in particular education and social awareness strategies, control/eradication measures, and habitat restoration.

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The IUCN/SSC ISSG contribution to Halting Biological Invasions in Europe

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The Invasive Species Specialist Group (ISSG) is a global network of scientific and policy experts on invasive alien species (IAS), organized under the auspices of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN). The ISSG established in 1994 is the oldest global organization dedicated to working on IAS issues. It currently has 196 core members from over 40 countries and a wide informal global network of over 2000 conservation practitioners and experts who contribute to its work. The three core activity areas of the ISSG are policy and technical advice, information exchange and networking. The overall aim is to encourage and mainstream IAS issues so they are addressed in an ecosystem context. The ISSG provides technical and scientific advice to IUCN and its Members in their activities on IAS especially in international *fora* (e.g. Convention on Biological Diversity (CBD), the Ramsar Convention, International Maritime Organization). The ISSG with the IUCN has recently signed a Memorandum of Cooperation with the CBD committing to support it and the Parties in making progress to achieve Strategic Goal B and Aichi Target 9.[2]

Having developed the first information system dedicated to IAS, the ISSG has deep institutional knowledge of IAS issues, their impacts and effective management including policy expertise. The main knowledge products of the ISSG are the Global Invasive Species Database (GISD) and newsletter *Aliens: the Invasive Species Bulletin*. The GISD is a rich repository of information on presence, impacts and management of IAS. The ISSG also engages with global practitioners and conservation managers supporting them in their IAS information needs both by making relevant information available and accessible, e.g. by operating an active list-service known as Aliens-L with over 1160 members. The ISSG membership when called upon provides technical and scientific advice to national and regional agencies and to civil society in developing policy and strategies and raising awareness to manage the risk of biological invasions. In Europe, the ISSG has regularly contributed to facilitate the development and the implementation of measures related to IAS collaborating with major institutions and key stakeholders. For example, at the regional level the ISSG has provided continued support to the European Commission (EC) on its work in the development of an EC legislative instrument on IAS. The ISSG has been collaborating regularly with the European Environment Agency (EEA) e.g. on the development of indicators and the realisation of technical reports on early warning systems, and on impact of IAS. The ISSG also has a long tradition of cooperation with the Bern Convention, with which it is collaborating in the development of several codes of conduct and guidelines focused on major pathways of introduction, such as zoos and aquaria, and hunting, and, on other thematic issues, such as protected areas. The ISSG has supported the development and update of DAISIE “Delivering Alien Invasive Species Inventories for Europe” as well as the establishment of the new East and South European Network on IAS (ESENIAS). At the national level, the ISSG has contributed to the development of a strategy for IAS in Croatia.

[2] Strategic Goal B: *'Reduce the direct pressures on biodiversity and promote sustainable use'*. Target 9 *'By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment*'.

The role of ESENIAS in IAS policy making in Europe

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ESENIAS (the East and South European Network on Invasive Alien Species) was established at the meeting "EEA/EIONET Workshop on Networking on IAS in West Balkan Countries and Their Neighbors" organized by European Environment Agency (EEA) in cooperation with the Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, University of Forestry and Ministry of Environment and Water of Bulgaria in Sofia on 17-18 October 2011. The idea of new network was discussed in two previous meetings in 2010: "EEA/EIONET Workshop on Invasive Alien Species in West Balkan Countries" in Zagreb, Croatia and "2nd Workshop on Invasive Alien Plants in Mediterranean Type Regions of the World" in Trabzon, Turkey. Current members of network are Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Kosovo under UNSC Resolution 1244/99, FYR Macedonia, Montenegro, Serbia and Turkey. It is expected that network will in the future include neighboring countries in Mediterranean and Black Sea area. ESENIAS brings together experts on biodiversity, environmental management and pest control from national and regional environmental and agriculture departments, and governmental and public organizations. The main goal of ESENIAS is establishing regional cooperation, with aim to aid in early detection, eradication, control and mitigation of IAS. Common database on IAS for the region is one of the main contributions of a new network, since for this region many data are missing or are not available on higher level. This will also be helpful in raising awareness among decision makers and the general public. The development of this network aims at a more effective implementation of the Aichi Target 9 of the Strategic Plan for biodiversity 2011–2020, adopted during the tenth meeting of the Conference of the Parties of the Convention on Biological Diversity (CBD COP10, which took place in Nagoya, Aichi Prefecture, Japan, in October 2010). Aichi Target 9 states that "by 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment". Without collaboration in region all these tasks will not be achievable. EU has been working on a dedicated instrument to manage threats of IAS on biodiversity and economic activities to reach to 2020 targets on biodiversity. In spite of preventive activities such as border controls, IAS are not only a problem for a given country or region. There are many examples of invasive alien species rapidly crossing political boundaries and causing problems in neighboring countries. For that reason similar policies should be developed on pan-European level. Currently covering EU and non EU countries ESENIAS have major role in this context.

Species distribution models predict range expansion better than chance, but are they meaningful? Implications to invasive species management

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The use of species distribution modelling (SDM) has grown exponentially in the last two decades and has shown its potential for biodiversity conservation and ecosystem management (Peterson *et al*. 2011) including studies with invasive and non-native species. We evaluate the capacity of SDM to predict the range expansion of six free-living deer species in Great Britain, three of them are non-native species. We assess whether SDM perform better than the geographical distance to the previously occupied localities (GD). Distribution data for the six deer species prior to 1972 were used to train the SDM models (ENFA, MAXENT, logistic regression and an ensemble model) in order to obtain ecogeographical suitability maps. Additionally, GD was considered as a proxy of the probability that a certain locality has to be occupied during an expansion process considering only dispersion. Subsequently, we analyzed whether the species increased their ranges between 1972 and 2006 according to the estimated suitability patterns and whether SDM predictions outperformed GD predictions. All SDMs predicted better than chance the species expansion (AUC>0.5) But the SDMs were not more informative in predicting species expansion than the simple distance to the previously occupied localities (Figure 1).

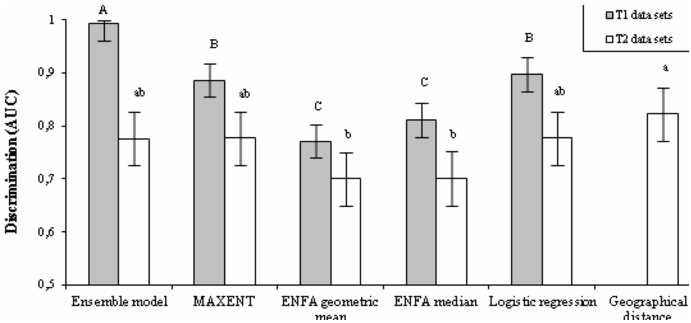

Figure 1. Discrimination capacity (AUC) of the modelling techniques assessed i) on the localities occupied up to 1972 and the unoccupied ones (training data, T1), and ii) on the new localities occupied between 1972 and 2006 and the still unoccupied ones (T2). Estimated marginal means (95% confidence intervals) obtained from general linear mixed models. Bars sharing the same letters (T1, capital; T2, lowercase) indicate techniques that did not significantly differ (p>0.05) according to a post-hoc Tukey's test.

Probably, spatial autocorrelation causes optimistic estimation of SDMs performance or also, the distribution of endotherm big-sized and ecologically plastic species – such as our study species – may be difficult to predict. Anyway, given that the SDMs worked better than chance, one could have been tempted to derive conclusions from their scarcely informative predictions. Consequently, these results could have implication over invasive species management programs and control measures. Costs of non-native species management are in the United States of millions to billions of dollars per year (Pimentel *et al*. 2005). So, not-well supported conclusions can cause economic losses, and even worst, management failures. This study shows that caution should be exercised when using SDM, as a model that performs better than chance may lack real significance and lead to wasted managing options efforts.

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Ecologically meaningful models for invasion: accounting for interactions between species and the environment

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In order to identify the principal processes driving plant invasion at regional scales, we modelled the response of 16 invasive plant species in south-eastern Australia with variables that indicate abiotic and biotic characteristics, propagule pressure and time. We used hierarchical models. After selecting 5 and 4 variables that best explained the occupancy and relative cover of invasive plants, respectively, we fitted new models in which the response to the environmental variables was modulated by plant species attributes. These latter models indicate whether the principal processes driving invasions vary among species as a function of their attributes.
Results suggest that time and native species richness, followed by temperature and propagule pressure surrogates, were the environmental factors that most strongly shape invasive species occupancy. Except for native species richness, the same results were found for invasive plant relative cover. Species attributes had a substantial effect in modulating species responses to one or more environmental factors. Overall, species residence time was the attribute that most strongly modulated species response to environmental variables.
Our analysis demonstrates the benefits of using a hierarchical approach to examine patterns of alien plant invasion. Using multispecies models that incorporate species attributes enables ecologically meaningful interactions to be identified. The fact that specific attributes modulate species responses to environmental conditions suggests that invasive plant management could target species with favourable traits for a particular environmental context. For example, in the margins of vegetation patches annual plants may be given management priority due to their high probability of establishment where disturbance is high.
By revealing interactions between characteristics of invaded environments and attributes of invading species, the approach used in this study will help to increase understanding of factors that affect invasion extent.

Modelling climate suitability for exotic plant pathogens: lessons learned after the emergence of *Mycosphaerella nawae* in Spain

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In recent years invasive plant pathogens have become increasingly important because of the growth in global trade and increasing biosecurity concerns. The primary method of protection worldwide is by the application of quarantine regulations. International Plant Protection Convention (IPPC) standards for phytosanitary measures recognized by the World Trade Organization (WTO) stipulate that a pathogen can be given quarantine status if this can be justified by pest risk analysis (PRA). Assessing the potential for establishment is a key part of the PRA process and the potential geographical ranges of exotic plant pathogens are estimated by different types of species distribution models applied to spatial climate datasets.

Circular leaf spot caused by the fungus *Mycosphaerella nawae* Hiura & Ikata is a serious disease of persimmon (*Diospyros kaki* L.f.) that induces leaf necrosis, defoliation, and significant yield loss due to premature fruit drop. *M. nawae* reproduces primarily by ascospores formed in the leaf litter, which are disseminated by wind and infect leaves in the presence of wetness and adequate temperatures. However, the specific environmental requirements for infection have not been determined and only laboratory data on spore germination rates are available (Kwon *et al*. 1998). The disease is endemic in those regions of Korea and Japan characterized by a humid-subtropical-type climate with a summer rainfall pattern and yearly precipitation of about 1,500 mm. In contrast to Korea and Japan, persimmon-growing areas in Spain are characterized by a semi-arid Mediterranean-type climate. Annual precipitation rarely exceeds 500 mm and summers are particularly dry. Classic climate matching approaches failed to predict the establishment of *M. nawae* in Spain, which was, however, recently detected causing severe epidemics.

As an alternative, we used the generic infection model for foliar fungal pathogens developed by Magarey *et al*. (2005). The model includes five parameters describing temperature and wetness duration requirements for infection. A Bayesian method based on Monte Carlo simulations was used to estimate parameter values considering both expert knowledge and the scarce experimental data available (Makowski *et al*. 2011). The model was applied to a dataset from a meteorological station located in the affected area in Spain. The results showed a probability of successful infection by *M. nawae* higher than 0.5 for 32% of the 672 wetness periods analyzed, clearly supporting the establishment and spread of *M. nawae* in the area of study.

The case of *M. nawae* in Spain illustrates some of the limitations of climate matching analyses for exotic plant pathogens, especially when these are based on restricted disease distribution records and a lack of detailed epidemiological data. The absence of the disease in an area can be a consequence of the absence of inoculum and not due to climatic constraints. Therefore, predictions for areas with dissimilar climates can be highly inaccurate, particularly in the case of diseases in their early stage of the invasion (Dupin *et al*. 2011). Moreover, climate comparison analyses rarely consider leaf wetness, which is a critical micro-environmental factor for the development of foliar fungal pathogens.

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Naturalization of garden plants as a result of the interplay of species traits, propagule pressure and residence time: a project introduction

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For many introduced species factors such as biological traits, date of introduction (residence time) or pathway of introduction are known in well-studied regions, but the level of propagule pressure is usually unknown. For propagule pressure several proxies are used in invasion biology, but hard data are extremely rare. High levels of propagule pressure or mass effect may overcome the series of barriers in the invasion process; this was also illustrated using neutral model.

The presented project is based on a novel approach that combines newly collated data from floristic inventory (used to obtain estimates of propagule pressure), a common garden study (to provide comparative information on species traits under standardized conditions) and exploration of historical sources (to account for the residence time of the species tested in the region), for a set of species differing in invasion success in the Czech Republic. By combining the above information sources in one model, we will determine the relative importance of species traits, residence time, propagule pressure and phylogeny in naturalization of species planted as ornamental in private gardens, and explore what is the interaction between (i) biological traits of species, and (ii) stochastic and socio-economic factors represented by the frequency of planting and time since introduction. At the species level, the project will identify particular species that are likely to become invasive, although their invasion may have not yet been realized, and provide managers and state authorities with information background for taking appropriate decisions.

Questions addressed by the project

- What is the propagule pressure of selected alien herbaceous species planted in private gardens in the Czech Republic expressed by frequency and duration of planting?
- What is the relative role of biological traits and propagule pressure (incorporating residence time) in determining the invasion success of alien species cultivated in gardens?
- Are existing weed risk assessment schemes applicable to the pathways of plant invasions, represented by deliberate planting in private gardens?

Using predictive models to improve the detection and monitoring of alien invasive plant species in heterogeneous landscapes

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Alien invasion, along with climate and land-use changes, is among the main drivers of biodiversity loss worldwide. Preserving biodiversity from negative effects of alien invasions requires tools to predict where and when they will occur, in order to protect species and habitats presumed to be at risk and to set up cost-efficient conservation and monitoring strategies. Niche-based modelling tools (e.g. the BIOMOD R platform) allow the detection of current and future areas of invasion under climate and land-use change scenarios, as well as the prediction of conflicts between alien species and areas, habitats or species of high conservation value. Here we present results from the application of an improved modelling framework that (i) accurately predicts how alien and invasive plant species are spatially distributed today and in the future, and (ii) identify which factors most explain patterns of spatial distribution. The resulting knowledge about direction trends and spatio-temporal dynamics of invasion will have practical applications in conservation and management programs, especially those that are aimed at mitigating impacts of invasive plants, land-use and climate changes in sensitive regions. Furthermore, our improved modelling approach will allow the forecast and early detection of changes in alien invasive species distributions, thereby providing essential information for optimising eradication programs and monitoring networks.

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A new wave of allergenic weeds knocking at the door?

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Plant invasions are a significant component of global change with far-reaching consequences for biodiversity, land use and human well-being. Some alien plant species are of particular concern for human health due to their allergenic pollen. However, there is a poor understanding if besides common ragweed (*Ambrosia artemisiifolia*) other closely related, but still rare species, may cause significant health problems in the near future, and which management options for halting their spread in an incipient invasion stage exist. Here, we focus on three allergy-inducing species of the Asteraceae, i.e. *Ambrosia trifida* (giant ragweed), *Artemisia annua* (annual wormwood) and *Iva xanthiifolia* (burweed marshelder). We provide an analysis of their invasion dynamics in Central and Eastern Europe (CEE). Based on > 2,000 distribution records, we reconstruct their spatio-temporal invasion history, habitat affiliation and analyse possible niche shifts. We apply an envelope modelling approach to assess the invasion potential under current climate and to project to which extent CEE might be prone to climate warming driven changes in invasion risk by these species by 2050. Finally, we assess the effectiveness of different management strategies to halt or slow down future spread using a cost-benefit-analysis.

What shapes giant hogweed invasion? Answers from a spatio-temporal model integrating multiscale monitoring data

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Biological invasions are complex phenomena driven by multiple processes at different temporal and spatial scales. Hence, process-based modelling approaches building on comprehensive interdisciplinary knowledge of an invasive species and utilising multiscale monitoring data appear particularly suitable for the study of biological invasions and assessment of the relative importance of the processes involved.

Heracleum mantegazzianum is one of the most invasive plant species in temperate Europe. It has been spreading fast in Germany since the middle of the 20th century and its invasion is still continuing. The biology, ecology and genetics of *H. mantegazzianum* have been studied extensively in an EU-project ("Giant Alien") from 2002–2005. The landscape-scale distribution of the species was mapped twice in 20 study areas of 1 km² in Germany. Hence, the required knowledge and monitoring data for building a process-based model were available.

We simulated the invasion of *H. mantegazzianum* with a spatiotemporal model that combined a life-cycle matrix model with mechanistic local and corridor dispersal and a stochastic long-distance dispersal in a cellular automaton. The model was applied to the habitat configuration and invader distribution of eight study areas. Comparing the simulations with monitoring data collected over seven years (2002–2009) yielded a modelling efficiency of 0.94.

In this study, we aimed at testing the significance of different processes of invasion by omitting or modifying single model components (processes) one at a time. Thus we found that the extent of *H. mantegazzianum* invasion at landscape level depended on both landscape-scale processes related to dispersal and on local processes which controlled recruitment success and population density.

Projections of the invasion improved significantly when we limited the recruitment success (100%→30%) or successionally decreased the carrying capacity of habitats (max → 0) over 30 years, compared to a model without these constraints. Further, we found that local dispersal reached farther than 10 m, i.e. farther than previously assumed, but appeared to be unaffected by wind directions. Long-distance dispersal together with local dispersal dominated the invasion quantitatively, while dispersal through corridors accounted for less invasive spread. Only dispersal along rivers made a significant quantitative contribution to invasion of *H. mantegazzianum*. The quantitative importance of corridor dispersal is probably limited, but corridor dispersal may still create some new invasion initials that afterwards grow through local dispersal.

We suggest that biotic heterogeneity of suitable habitats is responsible for varying invasion success and that successionally increasing competition leads to declining population densities of *H. mantegazzianum* in the course of several decades slowing down the spread on the landscape scale.

In a next step, we will use the simulation model to project the future invasion of *H. mantegazzianum* over a period of 100 years. Such projections may help to identify the potential future impact of invasive species and may, thus, inform prioritization of species for management.

Downscaling the predicted probability of invasion by alien plants from landscape mosaics to land cover classes in Northern Portugal

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Biological invasions are one of the main promoters of biodiversity loss worldwide. Preserving native biodiversity and ecosystems from invasion by alien species requires comprehensive studies and measures to anticipate widespread impacts and to protect species and habitats of high conservation value. Species distribution models (SDM) have been used in invasion ecology both to predict the potential distribution of invasive species and to forecast the threat to native species and habitats. One of the main constraints to the effective application of SDM for local management of invasion processes is the coarse spatial scale of many environmental variables that potentially determine alien species distributions. To overcome this limitation, we developed and tested a new framework for invasion probability allocation at the land cover patch level for *Acacia dealbata*, an alien invasive tree in the North of Portugal. The first steps of the this new method were carried out with an updated version of the BIOMOD R-package and consisted in the calibration of an ensemble model based on 1Km^2 species data, followed by a selection of the 1Km^2 grid cells predicted as presences. This final model was then downscaled into a 200m grid resolution using a direct approach downscaling technique and validated using independent field data for *Acacia dealbata* at a 200m resolution. Spatial projections of the 200m resolution models were then used to further downscale the probability of invasion to the land cover patch level using two different methods: i) an expert based judgment of the species habitat preferences in the region, through the comparison of the invasibility of the different land cover classes in order to rank those classes according to their susceptibility to invasion by *A. dealbata*; and ii) an analytical method based on habitat selection/preferences based on the spatial projections of the 200m resolution models. A consensus map was finally created by combining the maps obtained from the two methods. Using this approach we obtained, starting from initial predictions from a coarse-grain SDM, an improved map of invasion at the land cover level in complex, fine-grained landscapes of Northern Portugal. Our results are expected to improve local management of alien invasions by supporting prevention, control and eradication at the appropriate scales and management levels.

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Spatial patterns of invasion and potential distribution of *Fallopia* species at the regional scale: a case study from Southern Poland.

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Fallopia japonica (Polygonaceae) *F. sachalinensis*, and their hybrid, *F.* ×*bohemica* are a well-known East Asian perennial that are established throughout the Europe and North America. Their invasive success is primarily attributed to their ability to spread via clonal growth. However, sexual reproduction is more common than previously assumed. Fallopia became widely distributed and now occupies large areas of generally riparian or ruderal habitat.
Recently, the SDMs has gained popularity as an effective tool for early prediction of invasions. At the global and continental scales, climatic variables play a primary role in limiting species distributions and vegetation patterns and are useful predictors in SDM approaches. However, at the regional scale, other non-climatic factors (e.g. topography, land cover, transportation routes) may play an important role in spread and establishment of invasive species. In particular, the importance of anthropogenic factors for invasion patterns is emphasized by many authors.
The aim of this study was to identify the spatial patterns of invasion and predict potential distribution of three *Fallopia* species in Southern Poland. For this purpose, we used the Maximum Entropy algorithm implemented in the Maxent software ver. 3.3.3e. We chose this algorithm because it requires presence-only occurrence data and supports both, continuous and categorical environmental variables. As input data, we used a set of predictors related to topography, habitat distribution and anthropogenic factors. To calibrate the model we used coordinates of over 300 point localities of studied species from Silesia region in Southern Poland. The predictive power of model was tested using the area under the Receiver-Operating Characteristic (ROC) curve. We also estimate the importance of the input environmental variables in the model by using a jackknife procedure implemented in Maxent software.
The most suitable habitats of *Fallopia* species were identified along the major transportation routes, in urban areas and other habitats affected by human activities.
Results from this study hold promise for the development of proactive management approaches to identify and control areas of high abundance and prevent further spread of invasive *Fallopia* species in Poland.

Impact and management strategy for an invasive succulent plant (*Kalanchoe daigremontiana*) in a Neotropical arid zone

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Figure 1. Flowers of *Kalanchoe daigremontiana* (Photo by I. Herrera).

The biological invasions have a great impact on biodiversity and ecosystem functioning worldwide. *Kalanchoe daigremontiana* (Crassulaceae) is a short-live succulent herb native to dry zones in Madagascar (Figure 1). Outside its native range, this species can turn into a potentially noxious invasive plant. It can be toxic to domestic animals and wildlife, change soil properties and inhibit recruitment of native species. In Venezuela, *K. daigremontiana* has established in arid zones. At Cerro Saroche National Park (Lara State, Venezuela), this plant covers an area of ~ 20 ha. The restricted distribution of *K. daigremontiana* in the area suggests that their control is still feasible. Its rapid proliferation in Cerro Saroche is of great concern because: (1) we have evidence of the negative impacts caused by this species, and (2) the affected area hosts several species of plants endemic to the scarce arid zones distributed in the Caribbean. *K. daigremontiana* has several traits frequently found in exotic plants with high invasive potential: autogamy, high seed output (16000 seeds per fruit), clonal reproduction through plantlets, and capability to form large seed banks. Based on this reproductive profile, we predict that a significant reduction of the seed bank and the number of propagules could hamper the establishment of *K. daigremontiana* in the invaded areas. Based on empirical data, we derived a stage structured, stochastic and density-dependent model to identify characteristics relevant for its establishment. Sensitivity analyses revealed that the establishment of *K. daigremontiana* depends exclusively on plantlet recruitment. Because asexual plantlets reproduce in less than one year, populations are able to increase rapidly during the initial phases of invasion, when extinction risks are higher. Sexual seedlings, on the contrary, require a minimum of three years to reproduce. As a result, seedling recruitment contributes little to the transient dynamics of the population, and therefore cannot warrant the successful establishment of the species. Thus, the results of the model do not support the hypothesis that attributed the successful establishment of *K. daigremontiana* to its high fecundity and ability to form large seed banks. Simulations of various management strategies show that eradication through plant removal may only be achieved if harvest begins shortly after introduction. If a rapid response is not possible, reducing the survival and growth rates of plantlets through biological control is a potential alternative option. Thus, a strict control of dispersal of plantlets by humans and a continuous monitoring of new invasions should be the first priority for reducing further impact of this exotic on native species in Venezuelan arid zones.

GIS mapping of invasive plants in the surroundings of the river Ebro as it passes through Castejón (Navarra, Spain)

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The riparian environment of the river Ebro as it passes through Castejón (Navarra, Spain) is characterized by a high degree of anthropogenic disturbances, due to an intense agricultural and forestry uses. Among them, it should be noted the strong percentage of non-native and invasiveness plant species whose presence has been caused or favored by human activities. This stretch of the river belongs to a Mediterranean pluvioseasonal-oceanic bioclimate (Rivas-Martínez *et al*. 2002) and presents three vegetation series: *Rubio-Populo albae*, *Salico neotrichae* y *Tamarico gallicae*. Two of them are included in the EC Habitats Directive (Council Directive 92/43/EEC), with Natura 2000 codes 92A0 (*Salix alba* and *Populus alba* galleries) and 92D0 (Southern riparian galleries and thickets - *Nerio-Tamaricetea* and *Securinegion tinctoriae*-).

Botanical classic studies combined with the development of a digital structure by means of Geographical Information Systems (GIS) focused to vegetation made up the used methods. Firstly, a detailed GIS mapping (scale 1:1000) was developed using ESRI ® ArcGis™ 10.0 software and aerial photos obtained from Regional Government of Navarra (http://idena.navarra.es/ogc/wms.aspx). These data were checked in the whole area and combined with a floristic inventory, following known works (http://www.floraiberica.org; Aizpuru *et al*. 1999, Biurrun 1999) and using GPS dispositive in order to obtain update information. Invasive plants were studied using the same methodology and following other botanical works (Elorza *et al*. 2004, Campos & Herrera 2009).

In the covered area (300 hectares), 17 exotic species were detected, mainly located in nitrophilous grasslands (*Medicago sativa*, *Amaranthus albus*, *Conyza canadensis*) probably dispersed by sheep or located around the agricultural and forestry cultures (*Arundo donax*, *Ailanthus altissima*, *Robinia pseudoacacia*, *Sorghum halepense*) due to human activities and the rapid growth of these species in disturbed sites. In the sandy and stony areas near the river Ebro, some species as *Paspalum paspalodes*, *Amaranthus muricatus*, *Cyperus difformis* or *Datura stramonium* could have also a great development, as well as other species inside the river (*Azolla filiculoides, Didymosphenia geminata).*

This work can provide information of great relevance in order to prevent further dispersal in areas not yet affected, and even further from other geographical areas.

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Predicting the worldwide potential distribution of the boatman *Trichocorixa verticalis verticalis* (Fieber, 1851) (Order: Heteroptera; Fam: Corixidae)

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Trichocorixa verticalis verticalis (Fieber, 1851) is a species originally distributed in North America and the Caribbean islands. However, this boatman has been cited as an exotic species in different countries of Africa, Europe and Oceania. The aim of this study was to estimate worldwide areas with suitable environmental conditions for *Trichocorixa v. verticalis* so as to identify potential new areas of invasion.

We compiled all available information on the distribution of this species from literature in the last 100 years (1911-2011), the GBIF database and field sampling in some recently invaded areas. The dataset gathered contains 82 records where the taxon is present around the world, including both native and invaded zones.

Here, we estimated its potential distribution using both i) distribution models based on species records and relevant climatic data (identified using an ecological niche factor analysis (ENFA)) using a multidimensional envelope procedure (MDE), and ii) thermal physiological data derived from experimental analyses. As individual procedures to estimate species fundamental niches are likely to misrepresent the true range of climatic variation that taxa are able to tolerate, we made a combined potential distribution map showing the climatically inhabitable areas for *T.v. verticalis* using both methods (CPD). Then, as this species mostly inhabits water bodies related with marine and wetland environments, we refined this CPD map using altitude as a surrogate of marine-related environments. So, we deleted mountainous areas, i.e. all areas that present an altitude higher than the highest altitude at which the species has been detected. Thus, we obtained a potential distribution map (PD) showing climatically suitable lowland areas (Figure 1). Finally, Mahalanobis distances (Farber & Kadmon 2003) were calculated in order to obtain continuous climatic suitability values within this PD.

Isothermality and *Temperature Annual Range* were the most relevant climatic variables, and therefore these variables were used in the MDE procedure. *T. v. verticalis* seems to have inhabitable conditions in temperate areas along a wider range of latitudes, with an emphasis on coastal areas of Europe (including Mediterranean islands), Argentina, Uruguay, Australia, New Zealand, Myanmar, India, the western boundary between USA-Canada and some areas of the Arabian Peninsula and Persian Gulf.

Prevention is the most cost effective way to avoid biodiversity problems (Miller *et al*. 2005), and this work may aid the detection of new *T. verticalis verticalis* invasions. Our results predict likely expansion trends from recently invaded areas, as for example to France from Spain, or to other countries of Northern Africa from Morocco. Moreover our potential distribution map may be used as auxiliary tool, together with new field research, to confirm questionable records coming from areas identified as unsuitable by our model. Furthermore, present and potential distribution patterns seem to be related with the main trade routes and commercial harbours, especially between America and Europe. Whether this invasive species is causing loss of native aquatic invertebrate populations is still under study. Anyway, the widespread geographic range, the capacity to be passively-transported and the establishment of this species out of its native range may be considered as a threat to aquatic biodiversity, especially to native corixid species.

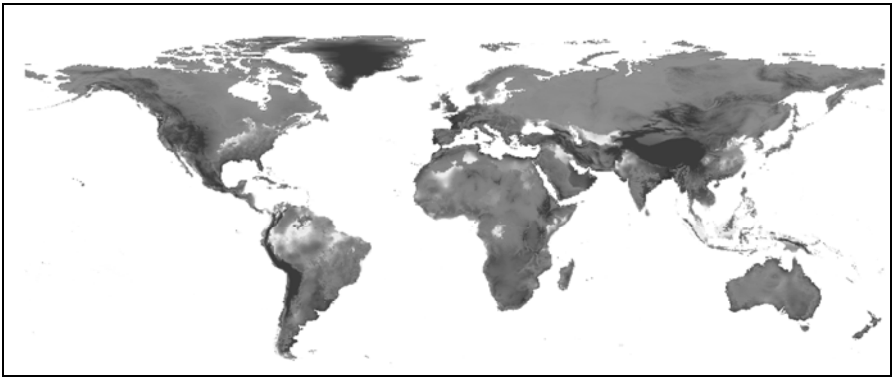

Figure 1. Worldwide potential distribution of the boatman *Trichocorixa verticalis verticalis*. From red colour (maximum suitability) to blue (minor suitability).

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Temporal trends in non-indigenous freshwater species records during the 20th century: a case study in the Iberian Peninsula

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Galicia (NW Spain) is a region with a high number of freshwater endemics, and probably the best preserved area concerning fish populations in the Iberian Peninsula (IP), where records of non-indigenous freshwater species are recent when compared to the rest of the Peninsula. Concerns arise as this region presents both a high biodiversity and a high number of endemic species linked to freshwater habitats.

Most of the data used in this study have been gathered from scientific literature, but we have included also many references of grey literature and information obtained during extensive sampling campaigns of researchers working at the Hydrobiological Field Station of the University of Santiago de Compostela (Galicia, Spain) during recent years. Organisms included in this review were grouped into vertebrates, invertebrates (excluding parasites) and macrophytes (excluding helophytes). We have not included records already considered as clear failed introductions by the authors.

Detailed analysis of introductions of those species with records after 1900 present in both areas shows that medium delay for their arrival to Galicia with respect to the IP was 12.75 ± 4.64 years for invertebrates (mean ± S.E.), 42.33 ± 27.55 years for vertebrates, and 56.75 ± 17.38 years for hydrophytes. Delays were up to 100 years for species introduced on the IP at the beginning of the 20th century, but the tendency adjusts to a decreasing linear regression, with species introduced on the IP after 1995 being almost immediately present in Galicia.

As pathways of introduction in Galicia, statistical analysis shows an outstanding role of aquarium trade on the arrival of species.

Temporal trends of introductions have been analysed using the software TRIM (TRends and Indices for Monitoring data; Pannekoek & van Strien, 2005). The cumulative number of NIFS from 1900 onwards in ten-year intervals was used; pre-1900 introductions were also estimated (EEA 2007). Temporal analysis of NIFS arrival reveals a steep increase in their number after 1970, both for the total number of species and for each of the groups. However, trends of cumulative number calculated using TRIM software (Figure) show that for total NIFS Galicia presents steeper slopes than the IP during almost all the studied period. Differences are clear for the 1931-1970 periods, even if Galicia was incorporating less NIFS than the IP. However, as trends reflect changes from the starting point of the series (1900), and the starting number of NIFS in Galicia was lower than that of the IP, small incorporations are shown as big changes. Interestingly, however, this tendency persists for the 1981-2009 periods, when number of NIFS had notably increased. Results show a clear deceleration in introduction rates of vertebrates, but a continuous growing trend for invertebrates.

Recent educational programs might be responsible for the reduction in the inflow of vertebrates, but there is still a need for the control of less conspicuous but equally harmful invertebrates and plants, as it will take longer to make both stakeholders and public aware of their detrimental effects on their new habitats.

Figure 1. Multiplicative slopes (±95% CIs) standing for the changes in the cumulative number of freshwater non-indigenous species (NIS) recorded in the Iberian Peninsula (IP) and Galicia as calculated by TRIM for total NIS.

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The top 10 worst invasive species in Europe: distribution and impacts on ecosystem services

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Socio-economic development, invasive species and ecosystem services are three inter-related elements that show complex though barely investigated synergies and trade-offs. There are more than 11,000 invasive species documented in Europe although ecological and/or economic impacts have been estimated for only a 10% of them (DAISIE project, www.europe-aliens.org). Amongst them, 10 species have been highlighted as having generating the highest costs, including five terrestrial, three freshwater and two marine species. Using these representative 10 invasive species, we investigated: i) their potential distribution in Europe according to Species Distribution Models (SDM) calibrated with the species' current distribution and a set of climatic, environmental and socio-economic indicators, ii) their main drivers of invasion, or the most important predictors determining their distribution, iii) the quality of baseline data in Europe for making well-informed assessment of the risks of invasive species for ecosystem services.

According to SDM calibrated with socio-economic factors (human influence, distance to ports and reservoirs), species probability of presence increased linearly with human influence and was highest in the vicinity of commercial ports, sharply dropping at distance > 200 Km. Bivariate logistic regression models confirmed the important role of socio-economic factors, which were able to explain more than 30% of the spatial distribution of the zebra mussel (*Dreissena polymorpha*), coypu (*Myocastor coypus*) and Canada goose (*Branta canadensis*). Most relevant predictors included road density, country GDP, closeness to ports and human degradation. In contrast, the brook trout (*Salvellinus fontinalis*) was associated with lowest levels of human disturbance. Insufficient information on human impacts prevented a correct assessment of the three marine species.

SDM calibrated with climatic variables showed higher accuracy scores and a negative relationship between species' presence and altitude, while a unimodal response was fit with minimum monthly temperature. A invasive 'hot spot map' combining all 20 SDMs pointed to the north of Europe, around the British Channel, the North and Baltic seas as the most vulnerable region to multiple invasions (UK, Germany, Belgium, France) (Figure 1).

The 10 species showed a wide range of impacts on ecosystem services, a number of which were positive for ecosystems and human well-being. In general, studies were surprisingly lacking in this area, and some effects, particularly negative economic ones, were assumed rather than thoroughly evidenced. Invasive species management requires prioritization, which should be based on the potential ecological and economic costs of species (both positive and negative), considered in the proper context of the invader and ecosystem and not assumed from previous cases. The Millenium Ecosystem Approach provides a useful framework to undertake such prioritization from a new perspective combining ecological and societal aspects. However, standard guidelines of evaluation are urgently needed in order to unify definitions, methods and evaluation scores.

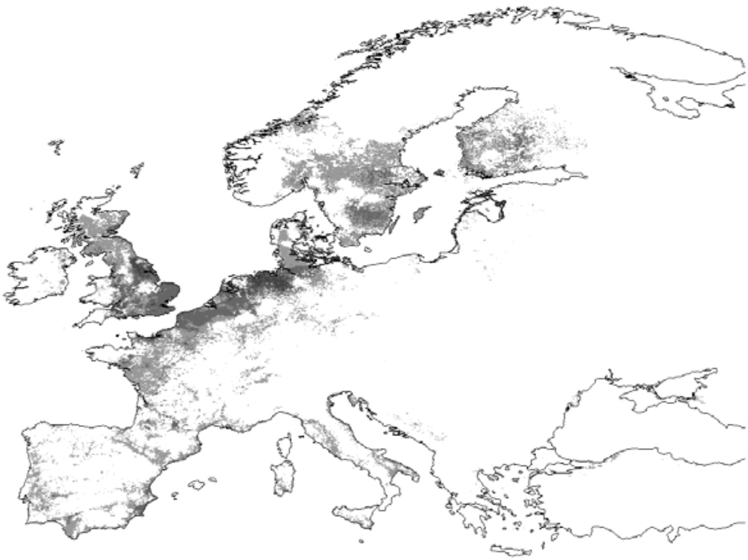

Figure 1. 'Hot spot' map of the 10 worst invasive species in Europe. This map is a combination of 10 maps developed by species using socio-economic predictors, and another 10 maps using climatic and environmental predictors. Darker grey areas represent a higher number of species predicted present.

The effects of bet-hedging on introduced populations

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Despite considerable current interest in biological invasions, the common life history characteristics of successful invaders remain elusive. Recent comparative studies of avian introductions (Sol *et al*. submitted) found evidences that successful invaders are characterized by life history strategies in which they give priority to future rather than current reproduction. Prioritizing future over current reproduction may confer benefits in novel environments through iterated reproduction, which spreads the risk of reproductive failure in uncertain environments (Stearns 2000). However, this may be achieved through a long lifespan or continuous breeding. We present a theoretical model that allows to explore how these bet-hedging strategies influence establishment in novel regions under different scenarios of demographic and environmental stochasticity, propagule pressure and perturbations. The model shows that bet-hedging strategies provide benefits even when the risk of reproductive failure is constant and that the benefits of a long lifespan or continuous breeding vary depending on the temporal scale of environmental autocorrelation.

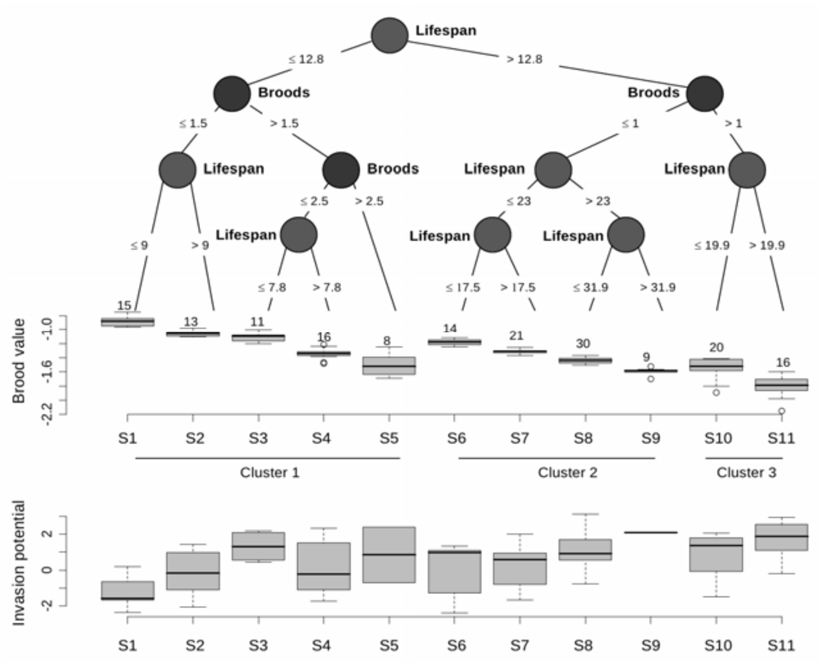

Figure 1. Tree regression describing brood value as a function of the number of broods per year (blue dots) and the maximum lifespan (in years, red dots). The tree regression recursively partitions data into sets that maximize the explained variance of the response variable (i.e. brood value) as a function of a set of predictors using regression methods. The predictors are number of broods, lifespan, clutch size and the fast-slow continuum, although the later two traits are not retained in the final model. The graphs in the bottom show the median and percentiles of the brood value and invasion potential for each strategy (from S1 to S11). Species that combine several broods per year with a relatively long reproductive lifespan and those that lay a single clutch per year

but have a very long reproductive lifespan are significantly more successful when introduced in novel regions than species with high brood values (GLMM: $P < 0.05$).

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Evaluation of two methods of weed risk assessment in Mediterranean semi-arid ecosystems

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We evaluated the performance of the Australian (AWRA) and Central Europe weed risk assessments (EWRA) in semi-arid Southeast Spain. The two methods were run against 176 alien plant species naturalized in the study area. We identified invasive species as those included in the lists of invasive species at different geographical scales (Andalusian, Spanish, European, and worldwide). A Receiver Operating Characteristic (ROC) analysis was performed to test the accuracy of the two Weed Risk Assessments (WRAs) in discriminating invasive and non invasive species. This method generates the ROC curve by plotting the rate of false positives (1-specificity) against the rate of true positives (sensitivity) across the range of cutoff point on an indicator scale (i.e., the AWRA score or the EWRA score). The predictive power of the WRAs was quantified by calculating the area under the ROC curve (AUCROC). In addition, we calculated the Youden's index, i.e. the point of the ROC curves that maximizes the ability for classification of the tests. The two WRAs tested were useful to differentiate between invasive and non-invasive species, with AWRA showing a set of features that provide a higher diagnostic power than EWRA. The AWRA rejected higher number of invasive species, but also a higher number of non-invasive species. To improve the accuracy of the AWRA, we used the maximum values of Youden' index. We increased the cut-off point for discriminating the invasive species from 7 to 9 for the category "rejected". Here, we did not adopt the WRAs as predictive tools, since they only were implemented for providing evaluations of the species that have yet been introduced in the area. However, based on the outcomes we propose the AWRA as an alert system to identify risk of species that have not yet escaped into natural areas or to inform regulatory environments to manage biological invasions. As EWRA is faster to implement than AWRA, we recommend EWRA as a preliminary step to get short-term results.

Risk assessment of non-native tree species permitted in forestry in Estonia

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The commercial usage of non-native species can leave a significant environmental impact, which is why the role of forestry in propagating the establishment of these species cannot be underestimated. The trees are planted abundantly and in a vast area, creating a propagule pressure aiding their naturalisation. In addition, species or their clones those are pest-free and most suited to the local climatic conditions and hence more invasive. Since the introduction of invasive alien species into a new area has been described as being one of the greatest threats to the maintenance of biological diversity, determining the likelihood of any species becoming invasive has become even more important.

According to the Ordinance of the Minister of the Environment, enforced in 2006, 13 non-native species are allowed to be used for forestry purposes in Estonia. These species were first introduced with the intention of using them in park woodland and in horticulture, not widely in forestry. The aim of this work was to assess the potential of the non-native species referred to above becoming invasive. To achieve this the most widely known weed risk assessment (WRA; Pheloung *et al*. 1999) system, originally developed for Australia, was used. This WRA system is applicable to all plant groups, performs well across a wide range of geographies and has been tested on woody plant species in temperate forest in Europe (Křivánek & Pyšek 2006). In this study, the WRA has been adapted for use in Estonia. Despite the lack of some specific information, enough questions were answered for each species to obtain a score and make a recommendation (accept, evaluate further, reject).

Based on the outcome of the research most of the species (nine out of 13) have the potential to become invasive and therefore should be rejected. Four species need further evaluation. No species were classified as accept. While analysing their characteristics, all species were found to have traits common to invasive species to different degrees. For example, all species tolerate the local climate and the soil while most are capable of self-fertilisation, producing viable seeds that are adapted to wind dispersal and reproducing by vegetative means. Some have form consistent seed banks and tolerate/benefit from mutilation or fire. All of this is supported by the fact that seven out of the 13 species have already been recorded as naturalised beyond native range and six of them are classified as being invasive or potentially invasive in other countries.

Nevertheless, some basic questions remain still unanswered: why are these 13 tree species permitted for use in forestry; how do they affect the local flora when grown widely; what features can trigger their invasiveness and should their use in forestry be (e.g. limiting the number and/or area planted; maintaining the quality of seeds/saplings used; regular monitoring; etc.). It is important to seek answers to these questions to reduce the likelihood of species becoming invasive and having a negative impact upon our environment.

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Prioritization of quarantine and exotic plant pests based on a risk ranking tool in France

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Intensification of world trade increasingly contributes to the introduction of quarantine and exotic plant pests that threaten crops in the European Union. Unfortunately the development of management strategies to mitigate the risk of their introduction, prevent their permanent establishment and limit their subsequent spread is dramatically limited by the availability of resources. Therefore prioritization efforts should be performed in a scientifically sound manner to identify the priority pests in support of decision-making. A pragmatic way to address this objective is to assess the phytosanitary risks represented by the plant pests. Thus, a risk ranking system was developed using explicit data-driven criteria and a semi quantitative scoring system. It allows rapid and transparent risk assessments which result in a pest prioritization in the French context (climate, crops, trade…). This tool has been applied for 100 selected pests. One of the uses of the ranking results is to plan the development of diagnostic protocols at the Plant Health Laboratory. We compared the pests ranking first and the pests for which validated diagnostic protocols are available. Diagnostic protocols already exist for top priority pests, which confirmed that this tool gives similar results to expert judgment used so far to set priority within the France. As a consequence, this system is an opportunity to prioritize needs to develop management strategies for emerging pests compared to already regulated pests ranked with a medium or lowest phytosanitary risk profile.

The Invasive Alien Plants of the Tuscan Archipelago (Central Mediterranean): the EPPO prioritization process

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In October 2010, the Conference of the Parties to the Convention on Biological Diversity adopted the Strategic Plan for Biodiversity 2011-2020 which includes the Aichi Biodiversity Targets.
Target 9 of the plan aims to achieve that by 2020 invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment. Plant invasions are often resulting in a significant loss in the economic value, biological diversity and function of invaded ecosystems (Lloret *et al*. 2004).
Nevertheless, within a particular nation, state, or region, only a relatively small proportion of the naturalized non-native plant species are recognized as causing, or having the potential to cause, significant damage to native biodiversity or economical activities. It is critical that we be able to determine which non-native species are causing significant negative impacts so we can prioritize the most harmful species for prevention and management to protect native species, ecological communities and human activities. Dramatic effects of plant invaders have to be expected on isolated habitats, such as those on geographical islands (Lloret *et al*. 2004). Particularly, Mediterranean type ecosystems constitute a hot spot of biodiversity. As management opportunities for invasive alien species are mostly restricted to early stages of invasion the early detection and prediction of invasive behavior have high priority (Gassó *et al*. 2010).
Towards this aim, we run the EPPO priorization process for invasive alien plants (Brunel *et al*. 2010) to produce a categorization and prioritization of 168 alien plant species in the Tuscan Archipelago. The EPPO standard procedure was adapted to the study area, and in general to the Mediterranean basin. Data required to perform the assessment derive from literature search and internet data-bases (distribution, spread, dispersal capacity, invasive behavior elsewhere, etc.). As result we produced the three main lists of the EPPO system, with 43 species in the list of invasive alien plants, 49 in the observation list and 76 in the minor concern list (Figure 1). Each assessment is associated to a level of uncertainty for each answer combined in a Bayesian network using the software GeNIe. This value can be used to perform a final ranking of invasive species and to concentrate control effort on species with higher invasiveness and lower uncertainty.
Next stage will be to test difference between the EPPO procedure and the (Australian) weed risk assessment, applied to the set of alien species for Tuscan Archipelago, as modified and applied by Gassó *et al*. (2010).

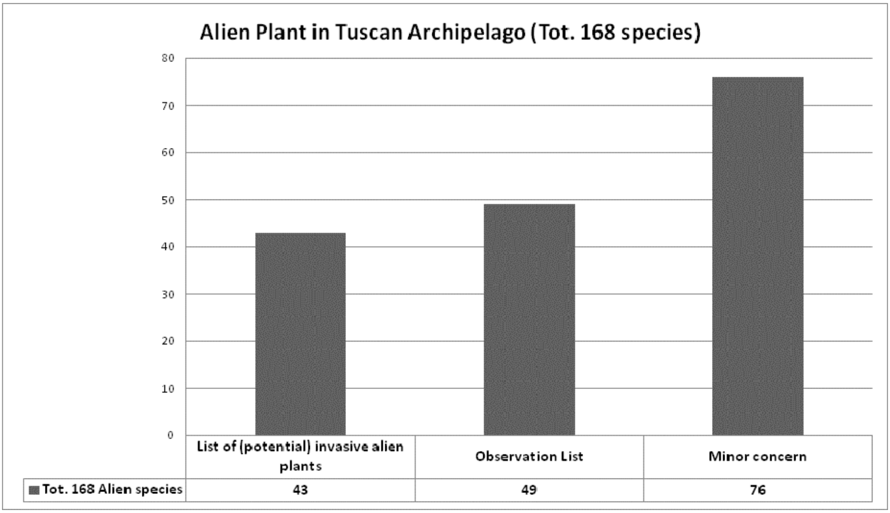

Figure 1. Outcome of EPPO priorization process for alien plants in the Tuscan Archipelago.

Aknowledgments

Co.R.E.M. – CUP E79E1000012000- Tuscan Archipelago National Park.

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How to distinguish the worst of the bad guys?

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Invasive alien plants are recognized as a problem of growing importance in Europe as alien plants are still being introduced deliberately or involuntarily. In order to reduce the threats of new plants becoming invasive, risk analysis should generally precede the importation or planting of species or potentially contaminated commodities as preventive actions are recognized as more efficient. For risk analysis, an EPPO (European and Mediterranean Plant Protection Organisation) pest risk analysis (PRA) scheme is available. As a full pest risk assessment is a time-consuming task and as the candidate species are numerous, a prioritization of invasive species for which a PRA is the most needed is necessary. As there is no existing widely agreed method to identify those alien plants that are considered invasive and represent the highest priority for pest risk analysis, such a prioritization process was developed in the framework of the EPPO ad hoc Panel on Invasive Alien Species (Brunel *et al*. 2010). The process consists of compiling available data according to pre-determined criteria and information related to invasion histories by the species. It is designed to produce a list of invasive alien plants that are established or could potentially establish in the EPPO region considering environmental, agricultural and economic factors, therefore favouring dialogue across different sectors. The process then determines which of these plants considered as invasive have the highest priority for PRA. This is done by considering the pathways that carry them and their distribution in the area under assessment (absent, or present but of limited distribution, as defined by the Plant Health principles). Such procedure is very helpful to harmonise the invasiveness concept and to enhance exchange of information between different countries. It also provides straight-forward and transparent criteria that can be presented to relevant stakeholders as well as the general public in order to justify and explain actions to be undertaken on invasive alien plants. It will therefore probably play an important role in the implementation of the future European regulatory instrument on invasive alien species. We introduce the main principle of the process and show the results of running the process with different sets of example species and at different geographical scales. The EPPO prioritization process is compared with other such systems such as GABLIS (Essl *et al*. 2011), the ISEIA protocol (Branquart *et al*. 2010), the horizon scanning procedure for invasive non-native plants in Great Britain (Thomas 2010) and the risk assessment scheme of potentially invasive plant species in central Europe (Weber & Gut 2004). The way the EPPO systems addresses the uncertainties and the predictive aspect of invasive alien species listing is also considered.

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When can risk assessment for deliberate introduction of natural enemies be satisfactory? The case study of *Iberorhyzobius rondensis*, a predator of the invasive pine bast scale *Matsucoccus feytaudi*

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Invasive species are the second major worldwide threat to biodiversity on the planet (Cory & Myers 2000). Biological control is considered an effective way for reducing the impact of invasive species, although it may have detrimental effects on native species. Thus, risk assessment for introduction or inundative release of natural enemies is a crucial step in any biological control program. In this work we present several steps of a risk assessment case-study and discuss the results. *Matsucoccus feytaudi* is a scale insect feeding on the maritime pine (*Pinus pinaster*), endemic of southwestern France, the Iberian Peninsula and North Africa. It became an invasive species in South-Eastern of France, Corsica and North Italy, where is currently causing severe diebacks (Jactel *et al*. 1996). The lack of natural enemies may partly explain *M. feytaudi* pest status in the invaded regions, thus being a suitable case for classical biological control. *Iberorhyzobius rondensis* is a lady beetle considered to specifically prey on this scale insect species (Branco *et al*. 2006). It has been recently discovered (Raimundo *et al*. 2006) and very little is known about its biology and its host specificity. In this work we evaluate the potential of *I. rondensis* as an agent of biological control of *M. feytaudi.* We first focused on the prey range of *I.rondensis* and the synchronization of its life cycle with that of the prey. Then we evaluated the possibility of inter-specific competition and intra-guild predation. Finally we assessed habitat use as a proxy of its host specificity. Survival, development and prey preference of *I. rondensis* larvae were recorded when fed on different insect prey species. Non-choice tests were also performed with adults. Survival and development rate of *I. rondensis* were always higher under the *M. feytaudi* egg masses regime. Neonate larvae could only survive if fed on this regime. Adults were more polyphagous than larvae. A close synchronization was found between the life cycles of both *M. feytaudi* and *I. rondensis* during a two years monitoring. Habitat is restricted to *P. pinaster* stands. Coexistence of the natural enemies of *M. feytaudi* was evaluated in the field. Focus was given to *Elatophilus crassicornis*, a specific predator of the pine bast scale in the Iberian Peninsula. The hypothesis of competitive exclusion was rejected since a strong association between the two predators was observed at both stand and tree levels. Intra-guild predation between both predators was neither observed in field or in laboratory trials. Overall*, I. rondensis* appears to be a good candidate for the biological control of *M. feytaudi*: it is highly specific, its life cycle is synchronized with that of the prey, and no evidence for inter-specific competition or intra-guild predation were found. The level of risk for non-target native species seems then to be very low. However we discuss further evaluations that could be done, prior to the release of the lady beetle in forest invaded by *M. feytaudi*.

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Decision support tools for invasive alien species in Galicia

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Galicia is home to many different ecosystems (terrestrial, freshwater, coastal and marine) characterized by a great diversity in terms of fauna and flora which are currently under the threats posed by non native introduced species. Within the framework of the Galician Strategy on Invasive Alien Species a Risk Analysis (RA) tool has been developed to support with technical information a) the designation of non native species as invasive under the Spanish legislation, b) the decision making on new introductions and c) the planning of actions to manage invasive alien species already established in Galicia. Two different contexts were taken into account: a) RA protocols *sensu stricto*, as a preventive tool in order to assess the risk posed by the introduction of a species, and b) the "post-border risk assessment", to prioritize which invasive alien species already established in Galicia must be managed over others, depending on their impact and feasibility of eradication or control (FAO 2006). The assessed species were divided in three groups: plants, aquatic species and vertebrates.
The RA protocol for plants was based on the Australian Weed Risk Assessment System (Pheloung *et al*. 1999), a method already validated for a large amount of species of different environments, which discriminates effectively invasive from non invasive species (Andreu & Vilà 2009). The RA protocols for aquatic (inland, brackish and marine) and vertebrates were based on those developed by the Alexander von Humboldt Institute for Research on Biological Resources (Baptiste *et al*. 2010). The methodology for establishing risk thresholds of invasion consisted of the following steps: 1) Assessment of the introduction risk levels for a set of species introduced to Galicia in the past which have shown a high capacity of invasion. 2) Repetition of the same assessment for species introduced at least 50 years ago and widely distributed in Galicia, which have not shown the ability to spread beyond the areas where they were originally introduced. 3) Calculation of the mean values of the risk associated to each group and corresponding dispersion measures, followed by the establishment of the thresholds for high and low risk of invasion. As well a security range of intermediate values which involves further analysis before making decisions (moderate risk) was established. In addition, a decision matrix to prioritize management actions was developed by means of a questionnaire that provides a score to establish whether the feasibility of controlling a given species is high, medium or low. Protocols were tested with 98 species (5 algae, 50 plants, 11 invertebrates and 32 vertebrates). Preliminary results were positive, since no false negative were obtained and only 3 cases were rejected. However further research is needed in order to simplify protocols (questionnaire), reduce uncertainties, and subjectivity in the responses and on possible false positives. On the other hand, the efficient implementation of this tool in Galicia, requires the development of other strategic issues such the establishment of responsibilities, reporting procedures, etc.

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Alien Macromycetes in Lithuania – an overview of the recent years

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Recent 10-15 years were notable in rising numbers of alien macromycete in Lithuania, as increased import of plants and plant-derived goods from outside the region combined with several recent milder winters have stimulated appearance and spread of some new fungi. Introduction of new fungi may be a result of a not intentional human activity such as transporting propagative plant material and of natural and semi-natural factors, appearance and activities of other alien and invasive species among them.

Appearance of new macromycetes are readily noted by general public as well due to several reasons – the new arrivals are conspicuous and often grow in anthropogenic habitats (parks, gardens, lawns), therefore in records of these species non-specialists play a core role. All new macromycete arrivals of the last two decades were first collected by non-mycologists. 21 years ago *Mutinus ravenelii* (soil saprobe, native to North America) was first recorded in a park, in Vilnius environs apparently introduced with packed soil substrate or potted plants. At present, six localities of this fungus are known, but in none of them *M. ravenelii* was found repeatedly. *Stropharia rugosoannulata,* another saprobe, was first recorded in 2011, also from garden in Vilnius environs. This fungus, widely grown in culture (but not in Lithuania) was introduced with wood chips, used in gardening. In the same year, there came first report of *Clathrus archeri* growing at a forest edge in Kartena environs (western Lithuania). This native to Australia saprobe is now widely spread in Europe, but is usually found in countries with milder climate. Several years ago an alien mycorrhizal *Boletellus projectellus* was found in Curonian Spit (western Lithuania), where it became abundant, but not yet spread to the continental part of the country (Motiejūnaitė *et al*. 2011).

Recent years has seen not only appearance of new macromycete species, but spread and establishment of earlier recorded aliens: a weak parasite on woody plants, temperate to tropical *Auricularia auricula-judae,* first recorded in 1959 (Mazelaitis 1962) and considered as very rare for five decades has lately increased in numbers along with spread of alien hosts – *Acer negundo* and *Sambucus* spp. and, apparently, following several milder winters.

We can conclude, that intensified movement of goods and people after the fall of the iron curtain at the beginning of the nineties of the 20th century in combination with a period of higher winter temperatures has provoked sudden boost of alien macromycetes in Lithuania.

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The actual number versus cumulative number of localities of invasive plants

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We tested statistically the similarity of the two data sets on invasive vascular plants collected along the Nitra river in 1999 and 2009. When comparing the actual number of populations and localities of each species, we found that at the significance level $\alpha = 0.05$ the difference in the number of sites is not statistically significant. On the contrary, when comparing the cumulative number of sites (the sites with extinct populations was not excluded), the difference at the same significance level was statistically significant. From this observation, we concluded serious faults of some commonly used research methods of biological invasions, which operate with a cumulative number of populations or locations.
The results show that the number of populations is almost constant, although cumulatively they have an increasing trend per time unit. Measurable differences can be seen at level of individuals in populations. Some species had approximately the same number as 10 years ago, others stagnated or even retreated in the year of the second observation. The number of species belongs to a group of important indicators of biological invasions and sometimes it is even considered as a global indicator. Due to the fact that the increase in the number of individuals can not be infinite, their redistribution is not possible after the saturation of phytocoenoses by species that are able to find resources there (space, nutrients, water, etc.) because of ecological barriers (unavailability of resources, competition, etc.). Traits of various species are different.
Further research should be focused on the observation in each year, so we would be able to eliminate statistically any fluctuations caused by weather conditions in the observed year.
The data must be accurate and up-to-date, because cumulative numbers may significantly distort the results of any research or monitoring.
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Impact of Plant Invasions on Ecosystem Processes: Where Does All the C, N and P Go?

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Exotic plant invasions have the capability to affect a range of ecosystem processes, including the biogeochemical pathways associated with C, N and P accumulation and loss (Ehrenfield 2010). In fact a characteristic of many large herbaceous invasive species is that they have the potential to significantly enhance C, N and P inputs into ecosystems, due to their high productivity (Ehrenfield 2010). Invasions by *Gunnera tinctoria,* for instance, can be associated with a 2-7 fold higher above ground biomass, compared to uncolonized areas and yet, surprisingly, there was no evidence of any increases in soil C, N or P, even when plants had been present for ~70 years. Similar soil C and N values were also obtained between areas invaded by *Fallopia japonica* and closely adjacent uninvaded localities. The question is where does the 'extra' C, N and P go? A nitrogen-fixing species, such as *G. tinctoria*, might be expected to enhance soil N (Vitousek & Walker 1989), so this may indicate tight plant-associated control of N metabolism, with significant N re-mobilization and storage prior to the major loss of aboveground tissues in the autumn. High litter production (Hickey 2002) indicates, however, that significant C/N inputs do occur in invaded localities. Possible routes for the loss of this 'extra' soil C and N include gaseous emissions, as either CO_2 or N_2O, or as dissolved C (organic C, CO_2 dissolved in water or HCO_3^-) or N (organic N, or NO_3-). Another potential route is *via* plant-facilitated gaseous emissions of CO_2, N_2O or CH_4 in species with a large air-space system (Brix 1990). Measurements of soil-derived CO_2 or N_2O emissions do not indicate, however, that these are significant routes, suggesting that dissolved losses of C and N are the more likely pathways. Recent evidence has indicated that dissolved C losses can make a significant contribution to the ecosystem C budget, but are rarely assessed (Kindler *et al*. 2011) and there is a wealth of data on the significance of P losses from different land uses. Associated redistribution of C, P or N to lower soil layers below the sampling depth of the measurements may also contribute to these results. An increase in the proportion of N as NO_3^-, with a reduction in the concentrations of NH_4^+-N, together with corresponding increases in soil pH and increases in oxygen availability due to decreases in soil moisture, may facilitate increased leaching of N in sites invaded by *G. tinctoria*. Dissolved C and N that are leached from invaded areas can subsequently be lost, in gaseous form as CO_2 or N_2O, at some distance from the source of production, so that any losses can have an impact over a large area. Overall, these results indicate some of the range of ecosystem processes that can be affected by exotic plant invasions and, importantly, show that the footprint of these affects may be considerably greater than that based on the invaded area alone.

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Context dependence of invasion impacts and their conservation relevance

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To prioritize management efforts and to substantiate their need, much attention has been paid lately to measure the effects of invasive plants on resident communities and invaded ecosystems (Pyšek *et al*. 2012, Vilà *et al*. 2011). Biodiversity impacts are usually quantified by comparing diversity indices between invaded and nearby uninvaded sites. However, these impact measures are rarely used to assess how strong specific nature conservation objectives are affected by the invader. Diversity measures alone might not always be suitable to answer this question as severe changes in community assemblages are not necessarily reflected by decreasing diversity. The suitability of impact measures for detecting biodiversity changes of invasions might depend on the invaded ecosystems and the invading species (i.e. the context of the invasion, Thiele *et al*. 2011) but studies that use context-dependent impact measures and integrate community turnover into the evaluation of invasion impacts are rather scarce. In this study we compare impact scores of major plant invaders (*Fallopia japonica, Heracleum mantegazzianum* and *Solidago canadensis*) based on diversity measures to those based on community turnover. We use a large dataset of paired plots from a semi-natural mountainous region in Germany that covers a variety of habitat types. To relate impact scores more specifically to conservation objectives, we assess turnover in two ways: first as similarity between invaded and uninvaded plots and second as the change in numbers of species that define the typical assemblage of the invaded community.

We show that (1) different abundances and the identity of the invasive species affect species richness and composition within different plant communities, (2) the impact of the same invading species can differ between invaded ecosystems and (3) the difference between diversity-based and community-based impact scores depends on both the invading species (Figure 1) and the invaded ecosystems. Our results demonstrate the need for context-dependent approaches when evaluating the relevance of invasion impacts for nature conservation. For setting priorities in the management of invasive species, it seems promising to incorporate the turnover of species groups with a high conservation value into impact measures.

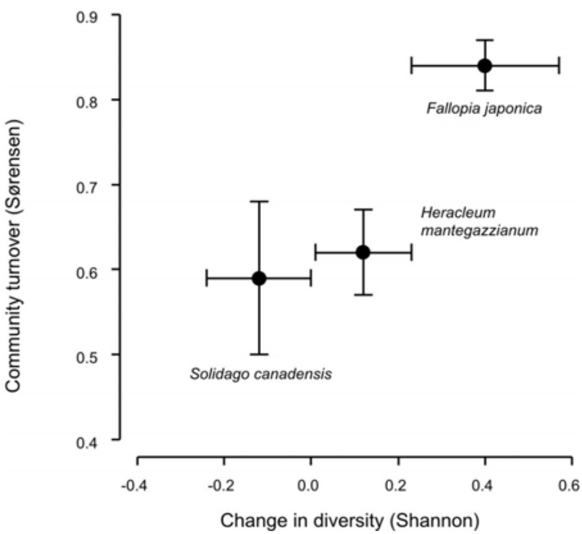

Figure 1. Mean change in Shannon diversity and community turnover (Sørensen dissimilarity) between invaded and uninvaded plots for three invasive species. Error bars show 1 SE.

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Soil saprotrophic fungal diversity under *Fallopia japonica* invasion

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Fallopia japonica is included among the organisms that can transform the ecosystems visually, structurally, and chemically (Aguilera *et al*. 2010). Our recent studies confirm a widely shared hypothesis, i.e. the main cause for plant diversity loss is the competition for light caused by the dense above-ground biomass much more abundant than the one produced by adjacent native vegetation, thus leading inevitably to elevated litter production too (Dassonville 2008). Low decomposition rate of *F. japonica* litter has been detected but knowledge on the correlation between its litter decomposition rate and associated soil microbial decomposers is still lacking. The aim of this work was to assess differences between mycoflora isolated from *F. japonica* and native vegetation litter.

To study the saprotrophic mycoflora associated with decomposing litter we conducted a three-factorial field litterbag experiment covering 13-months period. Litterbags containing four litter mixtures, two for the invasive species and two for native prairie species, were placed in two stands of decomposition – under *F. japonica* vegetation, and under native prairie vegetation. We isolated and identified the associated saprotrophic mycoflora from the remaining litter in spring (April) and in autumn (September), respectively four and eight months after insertion of the litterbags in the field. The fungi isolated from the four litter types differed in total load and in taxa diversity. Total load of saprotrophic fungi isolated from litter depended more on litter type than on stand of decomposition. As for fungal diversity, we found strong effects both of litter type and of decomposition stand. Native litter types were associated with a higher number of fungal taxa when decomposing in the own decomposition stand. The same pattern was observed for *F. japonica* litter types. In addition to several fungal species common either within litter types, or within decomposition stands, we identified some taxa exclusively associated with native prairie litter or *F. japonica* litter. For example, *Epicoccum nigrum* and *Phoma* species were present in the soil of both decomposition stands, but *E. nigrum* was specifically associated with native litter, whereas *Phoma* species were isolated only from *F. japonica* litter. Differences in the saprotrophic mycoflora diversity between the two studied stands suggest that *F. japonica* may shape the soil fungi composition, for example through its very high C/N ratio and other chemical components, i.e. secondary metabolites. Studies on allelopathy of *F. japonica* on other plant species revealed a high capacity to depress seed germination and growth (Murell *et al*. 2011), but little is known on the effect of its secondary metabolites on soil mycoflora. Our results may reveal another important mechanism underlying the invasion success of this species.

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Soil microarthropod communities under *Fallopia japonica* and native prairie vegetation

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The main effect of the invasion by *Fallopia japonica* is the exclusion of native plant species and the formation of dense monospecific stands. Recent studies on *F. japonica* prove that plants are not the only trophic level affected by the invader in the novel habitats. It has been also proven that it interferes negatively with invertebrate assemblages (Gerber *et al*. 2008). Other studies demonstrate that the species modifies soil chemical and physical characteristics and alters the ecosystems mainly by the production of abundant biomass and litter compared to other resident species, and by the secretion of secondary metabolites and allelochemicals.

In our work we hypothesized a parallel reduction of plant species richness and equitability and edaphic fauna in a stand invaded by *F. japonica*. In fact edaphic microarthropods, that spend all or the majority of their life cycle in the soil, play a key role in soil functioning and show clear sensitivity to soil disturbances and degradation. Moreover, they are influenced by the above ground vegetation: higher edaphic fauna diversity is linked to richer vegetation compared to monospecific stands (Menta *et al*. 2011a).

Plant species occurrence and percentage cover and soil microarthropod communities were detected in an area heavily invaded by *F. japonica* and in the adjacent native prairie at 680 m a.s.l. in a north-western Italian site. Soil fauna sampling consisted in nine top soil cores (100 cm^2 per 10 cm in depth) collected in October 2011 in invaded and uninvaded areas. Microarthropods were extracted by using Berlese-Tüllgren funnels and the obtained specimens were identified at different taxonomical levels and counted. Microarthropod abundances, Acari/Collembola ratio, biodiversity indices and QBS-ar index were calculated.

Microarthropod communities characterization in the invaded and uninvaded stands differed in terms of observed taxa and their abundances. In *F. japonica* stand we detected some groups well adapted to soil life, such as proturans and pauropods, and some predators as pseudoscorpiones and centipedes. Species diversity and soil biological quality in the prairie showed similar results to previous studies carried out in grasslands (Menta *et al*. 2011b).

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Distribution and invasiveness of the alien plant *Helichrysum petiolare* Hilliard & B.L. Burtt (Asteraceae) in Northwest Iberian Peninsula

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Despite of the general concern on biological invasions and recent studies focused on data compilation for a better knowledge on the issue, the potential invasive behaviour of a certain alien species is sometimes undervalued and considered merely as naturalized. Here we present accurate data on distribution, habitat invasion and invasiveness of *Helichrysum petiolare*, an alien known to occur in the North-West Iberian peninsula since the mid twentieth century but not described as an invasive species until recent years (Fagúndez & Barrada 2007).

H. petiolare is an evergreen shrub densely covered by a woolly indumentum. It is native to the Cape region in South Africa, where it occurs mainly on forest edges. *H. petiolare* has been widely used as an ornamental plant and has become naturalized in several countries throughout the world such as the U.S. and New Zealand. In Europe, the species occurs in the U.K., Sweeden, Corsica (France), Portugal (Madeira and continental) and Spain. Localities in Northwest Spain are known since 1974, cited from Tambo Island at the Pontevedra Ria, and later it was cited from both sides of the Eo Ria and Ferrol area (Figure 1). However, it has not been included in recent reviews such as the Spanish exotic plants list by Sanz Elorza *et al.* (2004).

We have reviewed all available information and conducted a field survey to establish the actual distribution of the species in Galicia (Northwest Iberian Peninsula). Data of occurrence, abundance and invaded habitat were recorded and implemented in a 1x1 km cell grid. Moreover, one of the main populations (Ribadeo) was studied and 56 patches occurring in an overall area of ca 3000 m^2 where categorized for invaded habitat. At the region level, *H. petiolare* was recorded at a total of 26 cells (Figure 1).

Most populations occur within metres from the sea shore at a maximum altitude of 250 metres above sea level. Invaded habitats were mainly tall shrubs with gorse (*Ulex europaeus*) (presence in 47.8% of cells) and anthropogenic habitats such as road verges (43.5%). Other affected habitats were *Eucalyptus globulus* plantations (21.7%), other afforested habitats (17.4%) and thorny scrub with *Rubus* (8.7%).

New occurrences recorded, many nearby previous known areas, suggest that the species is spreading. The species is associated to *Eucalyptus* plantations mainly in the Ferrol area, and probably benefits from forest management practices such as shrub cutting that spreads fragments, enhancing clonal vegetative reproduction. Moreover, the species presents a high capacity to post-fire regeneration. Seedling emergence has been observed in scrub clearings. We conclude that, although the invaded area is still scarce, *H. petiolare* is a strong invader in our studied region that interacts with natural habitats and human economic and social activities such as forest practices and wildfires. Deeper studies are needed and control plans for the species should be implemented.

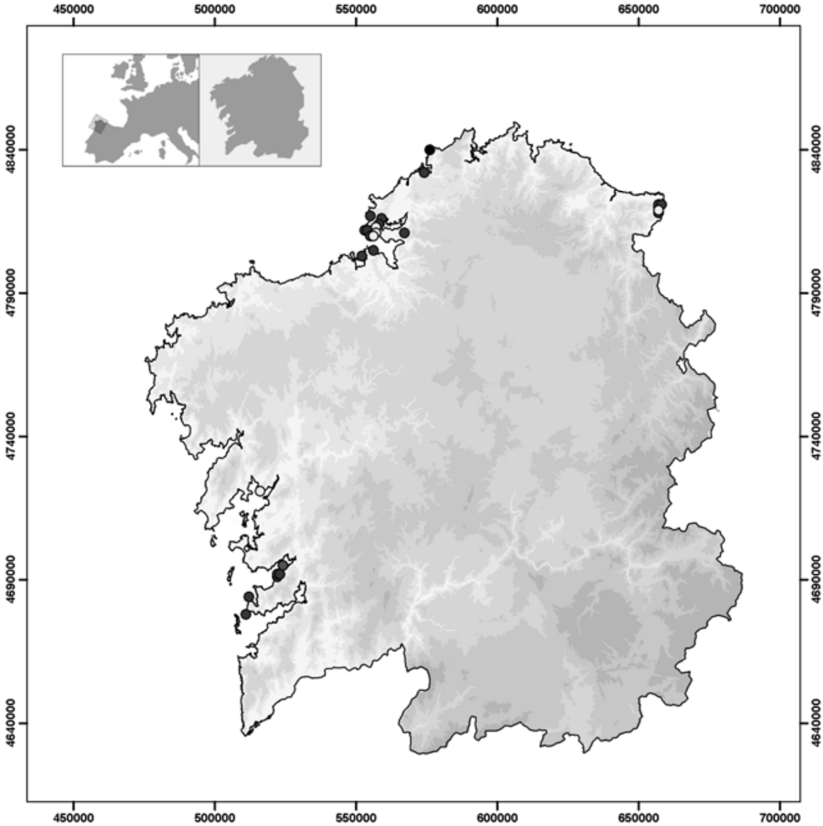

Figure 1. Distribution of *H. petiolare* in Galicia, NW Iberian Peninsula in a 1x1 km grid. Blue dot: first record (1974). Yellow dots: 1990s references. Black dot: 1980s reference not found. Red dots: Recent records (after 2000).

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Changes in soil quality in response to the invasion of *Carpobrotus edulis*

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The functional capacity of the soil microbial community varies among soils dominated by different plant species (Kourtev *et al*. 2002). Thus, when the species composition of a community changes due to the invasion and spread of an exotic, there are consequent changes in nutrient cycling processes (Ehrenfeld 2003).

Carpobrotus edulis (L.) N.E.Br. is a perennial and succulent clone plant native to South Africa (Albert 1995). *C. edulis* presents different plant size, spatial distribution, litterfall masses, descomposition rates and plant functional type (CAM metabolism) than those of native plants. Thus, the changes in the quality of soil microsites could involve a great impact on plant community composition, diversity, succession and microbial community (Donath & Eckstein 2009).

With the aim of asses the soil quality status in dune ecosystems invaded by the exotic *C. edulis* we (i) conducted experiments to determine the changes in soil characteristics and nutrient availability because of the presence of the invasive *C. edulis* and we (ii) tested the possible changes in the nutrients cycle (N, P and C), comparing extracellular enzyme activities (β-1,4-glucosidase, phosphatase, urease and dehydrogenase) in soil from native and invaded areas in a broad range of dune ecosystems of the Iberian Peninsula.

We found significant differences in pH, salinity values and nutrients content in soils invaded by *Carpobrotus edulis* compared with native soils. We also found significant differences in soil enzymatic activities. So, the presence of the invasive plant *C. edulis* constitutes a threat to the maintenance of the processes and functioning of sand coastal dune ecosystems.

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Effect of the invasion of *Spartina densiflora* on the benthic metabolism of coastal ecosystems

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Spartina densiflora is an exotic southamerican cordgrass that has invaded the marshes of the SW Iberian Peninsula. With a wide canopy, its dense tussocks form monospecific stands, replacing autochthonous species. This study assesses whether turnover rates (P/B) are modified by the invasion of this species and the potential implications on the energy flows in the ecosystem.
Populations of the endangered native species, *Scirpus maritimus* (*Sm*), *Scirpus litoralis* (*Sl*) and *Juncus subulatus* (*Js*), which are geophytes that lose their aerial biomass every year, were selected. Five stabilized monospecific populations of *Spartina* and a sixth population without initial aerial biomass after fire were also selected. Their aerial biomass (B), net aerial primary production (NAPP), turnover rate (NAPP/B) and turnover time of aerial organic matter in the plant were measured, estimated over cohorts of stems and leaves.
Spartina reached biomass values above 8000 $g \cdot m^{-2}$ in stabilized populations, between 3 and 11 times the aerial biomass of native species.
It was not the same for the production values. For the geophytes, the maximum values of biomass at the end of summer were those of their annual aerial production. These ranged between 1731 (± 196) $g \cdot m^{-2}$ (*Js*) and 788 (± 79) $g \cdot m^{-2}$ (*Sl*). However, in the *Spartina* populations, in general, the production values of the mature stabilized populations did not surpass those of the autochthonous species in 2011. Only when *Spartina* recolonized bare marsh mud spaces after fire, its populations reached production values near 700 $g \cdot m^{-2} \cdot year^{-1}$ during their first growing season and above 5500 $g.m^{-2}.year^{-1}$, during their second growing season. The analyzed data show that when *Spartina* retrieves empty spaces, its biomass grows very quickly and within 2 years it may reach the maximum values of stabilized populations. Its production values, which may be 10 fold from the first to the second year, up to 11 times higher than those of the native species, decrease from this point down to values similar to or lower than the native species and the turnover rates (NAPP/B) decrease at 0.2 $year^{-1}$.
After one year, more than 50% of the dead stems remain standing and more than half of the leaves stay in the stems. It was estimated that more than 70% of the biomass fixed in stems of *Spartina* may remain held within the population for more than 670 days, and the residence time of a leaf, from birth to fall, ranges between 420 and 767 days. In both cases (stems and leaves), the turnover time surpass and even double those of aerial biomass of autochthonous geophytes, which completely regenerate every year.
These values confirm *Spartina* as a sink of resources in the ecosystems it invades, acting as an energy and nutrient trap and disturbing the trophic processes. The high biomass values and the low turnover rates it reaches within few years make *Spartina* a very stable species in the face of the environmental fluctuations characteristic of the Mediterranean climate, which favors its presence and expansion.
Research funded by the National Parks Authority (Organismo Autónomo de Parques Nacionales, ref. OAPN 042/2007) of the Spanish Environmental Ministry.

Impact of the invasion of *Spartina densiflora* on the marsh invertebrate community (Insecta and Aracnida) of the Doñana National Park (SW Spain)

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At the Doñana National Park, dykes built in the 1980s to isolate the marsh from the tidal influence are going to be permeabilized. This will allow the expansion of *Spartina densiflora*, a very competitive clonal species that invades Atlantic coastal marshes of the SW of the Iberian Peninsula and replaces native species. Its clonal growth, in phalanx, allows the creation of compact clumps, with very high stem densities, which exclude the presence of other plant species. This study assesses whether the invasion of *Spartina* alters the invertebrate community linked to the vegetation, due to both the structural changes in the plant matrix and to the increase of the tidal influence.

The study was focused on terrestrial insects and arachnids. During July, August and September 2011 autochthonous populations of *Scirpus maritimus* (*Sm*), *Scirpus litoralis* (*Sl*), *Juncus subulatus* (*Js*) and *Arthrocnemum macrostachyum* (*A*) were sampled; the first population with partial tidal influence and the other three isolated from it. Four populations of *Spartina* were also selected, three with direct tidal influence and one without it. Individuals were identified and quantified at the family level. The density of individuals collected, richness, the Simpson index and the Sorensen´s similarity index were calculated for the families. During July, densities in the populations of native species were higher than in populations of *Spartina* and the opposite in August and September. The highest monthly values of individual density coincided with the highest monthly values of family richness, but the diversity values did not followed this pattern. In general, the populations of *Spartina* showed the highest diversity values. Perhaps the seasonal durability of the aerial structures of *Spartina* (*Sm*, *Sl* and *Js* are geophytes that lose their aerial part after summer) and the greater spatial availability (high phalanx stem density), as a structural support for the invertebrate community, could be plausible reasons that count for these diversity values.

On the other hand, the similarity indexes did not go above 50%. The invertebrate community of the population of *S. maritimus*, with tidal influence, showed the greatest similarity with those of the populations of *Spartina*. Of 33 identified families, 29 were recorded in the populations of *Spartina* and 25 in the populations of native species. Four insect families (Buprestidae, Noctuidae, Pyralidae and Chrysopidae) are present in the native species but not in any of the populations of *Spartina*, thereby, the replacement of autochthonous species by the exotic species could make them disappear.

Seven insect families (Aphididae, Reduviidae, Carabidae, Thripidae, Acrididae, Agromyzidae and Calliphoridae) and one arachnid family (Agelenidae) of the populations of *Spartina*, are not present in the four native species, thus it is possible that their arrival is linked to the invasion of the exotic species. The first six of these families are in populations of *Spartina* with tidal influence, thereby, the increase of tidal influence on the Doñana Marshes could increase their distribution scope. In addition to the latter, five more families should be considered (Culicidae, Muscidae, Cicadelidae, Cerambycidae and Arctiidae) which, even though they were recorded in populations of *Spartina* with tidal influence and in that of *S. maritimus* (also with tidal influence), they are not present in the other three populations of the native species (*Sl*, *Js*, *A*).

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Mechanisms behind the spatial distribution of 15N patterns occurring after the invasion of dune systems by *Acacia longifolia*

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Species belonging to the genus *Acacia* (e.g. *Acacia longifolia*, *Acacia saligna*, *Acacia dealbata*) have proven to be some of the most aggressive invading species, with vastly negative effects over Portuguese ecosystems. In fact, Acacia spp. have the potential to rapidly transform ecosystems by fixing nitrogen, changing fire regimes and altering community dynamics, an thus it has been suggested to consider these species “ecosystem transformers”. Recently, the group integrated in this study tested the usefulness of nitrogen isoscapes ($\delta^{15}N$) for quantifying the alterations in community functioning following *Acacia longifolia* invasion (Rascher *et al*. 2012). The study based on combining native species foliar ^{15}N with spatial information regarding plant location using geostatistical methods, demonstrated that it is possible not only to trace the N-focus point (*A. longifolia* individuals or small Acacia stands) as well as the area impacted by exotic N-addition into the surrounding native vegetation. Under limited distribution, we know that the impact area is larger than we thought (Rascher *et al*. 2012), expanding their area of influence than the canopy cover. Moreover, the same study performed with the native legume *Stauracanthus spectabilis* showed that there is no spatial impact, thus no pattern in ^{15}N signatures.

Accordingly to these recent findings, our main goal is to clarify the mechanisms behind the spatial distribution of ^{15}N patterns occurring after the invasion of dune systems by *Acacia* species as described by Rascher *et al*. (2012). For that we performed a comparison of the soil and litter qualities below the exotic nitrogen fixing species *Acacia* and the native legume *Stauracanthus spectabilis.* Soil characteristics such as temperature, soil humidity and respiration, proportion of bare sand to sand in direct contact with the roots as well as root mass and litter mass were analysed and the obtained results were related to the distance of both exotic and native legumes. Given that there are indications of a considerably higher ground biomass beneath *A. longifolia* accompanied by higher humidity and respiration, we predict that the extensive microbial community could contribute to the transport of nitrogen between exotic and native shrubs.To test this hypothesis, tissue staining was performed on the *Acacia* and the *Corema album* roots and the microbial community was observed with DNA sequencing techniques. Accordingly, to the presence of a common partner, controlled box experiments were performed, using different nets that either exclude roots or hyphae. Parallel to that, plant chlorophyll a extracts were undertaken to observe $\delta^{15}N$ changes in a time dimension, and therefore being used as a tracer molecule. The results indicate that nitrogen transport is not only passive by bulk flow or diffusion, but also flow through the hyphal network and other soil biota groups, which will contribute to the observed $\delta^{15}N$ signatures and the respective nitrogen transport.

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Quantifying community-scale impacts of the N2-fixing invasive *Acacia longifolia* using 15N isoscapes

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The exotic N_2-fixing *Acacia longifolia* is highly invasive in Mediterranean dune systems. In the presence of this invader, ecosystem structure and functioning in terms of carbon, water and nutrient balance of the native system are substantially altered (Rascher *et al*. 2011a, b, Hellmann *et al*. 2011). However, the spatial dimension of these alterations is largely unknown.

Here we show that massive N input by *A. longifolia* to a nutrient-poor Portuguese dune system can be traced using spatially resolved information on native plants' stable nitrogen isotopic signature (i.e. ^{15}N isoscapes). We found isotopic signatures of N to differ strongly between the native system ($\delta^{15}N \approx -10‰$) and the atmospherically derived N from N_2 fixation, which has an isotopic signal of ≈0‰. Thus, sources of N for plants could be readily distinguished. *A. longifolia* phyllodes had a signal close to the atmospheric value indicating a high N_2-fixation rate in the invasive species (Hellmann *et al*. 2011). Leaf $\delta^{15}N$ of a native, non-fixing species, *Corema album*, was increasingly enriched the closer the plant grew to the invader, indicating uptake of N derived from decaying *A. longifolia* litter. The enrichment was evident far beyond the stands of the invader, demonstrating that *A. longifolia* affected N budgets of native species up to a distance of 8 m exceeding the margin of the canopy. Furthermore, using the isoscapes approach, we were able to quantify the total area of N enrichment and could thus show that the area affected by invasion was at least 3.5 times larger than the area actually occupied by the invader (Rascher *et al*. 2012). Within the same spatial range, growth of *C. album* was enhanced and native species diversity declined (Hellmann *et al*. 2011). However, a native N_2-fixing species had no such effects.

Our study highlights the need to account for spatial scales when studying ecosystem influences of invasive species. Furthermore, we demonstrate that the use of stable isotopes provides a means for rapidly and efficiently obtaining spatially resolved data sets on the community level, which are a valuable tool to trace functional alterations caused by plant invaders.

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Different impact of above and belowground allelochemicals released by the invasive mimosa (*Acacia dealbata*) on soil functional diversity

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Acacia dealbata Link (*mimosa*), an Australian tree legume, is one of the most invasive species in south-eastern Europe, southern Africa and South America (Lorenzo et al. 2010a, Richardson & Rejmánek 2011). The invasive success of *mimosa* is partially attributed to its ability to release allelopathic compounds that are detrimental for native understory species (Lorenzo *et al*. 2010b, 2011), but the allelopathic effect on soil microbes has been little explored. Soil microbiota is an important factor in determining the structure and dynamics of plant communities. Soil microbes can be affected by exotic allelochemicals and can also play a role in the fate of these allelochemicals released into the soil (Inderjit & van der Putten 2010).

Our hypothesis was that *mimosa* releases allelochemicals that lead to changes on soil microbial community function. We used natural concentrations of rainfall leachates and root exudates to assess the bioactivity of these allelochemicals on soil microorganisms in native Mediterranean pine and mixed forests. We used aboveground and belowground allelochemicals separately in order to determine the allelopathic contribution of each fraction.

Aboveground allelochemicals: soil samples collected in pine and mixed forests (Coimbra, Portugal) were treated either with acacia canopy leachate or the corresponding canopy leachate. Leachates of *mimosa* were collected during its flowering period, since this is the peak of production and release of allelochemicals for this species. Belowground allelochemicals: seedlings of *mimosa* were grown in soils from pine and mixed forests. Activated carbon was added to half of each soil type to adsorb allelopathic plant exudates in the soil. In both experiments, functional genetic diversity of soil microbial communities was analyzed using Biolog Ecoplates™.

Aboveground allelochemicals released by *mimosa* clearly modified soil bacterial functional diversity in the pine forest where the soil samples watered with the native leachate consumed different carbon sources than soil watered with acacia leachate. However, the soil microorganisms of mixed oak forest were insensitive to allelochemicals activity. No effects of belowground allelopathic compounds exuded by the mimosa were detected in any of the studied soils.

The results obtained partially support our original hypothesis that the allelopathic compounds of *momosa* are responsible for changes in functional diversity of soil microbial communities. Our results show that the allelopathic effects of the *mimosa* depend on the ecosystem and allelochemicals type. Allelopathy was more important for the bacterial community in the pine forest. On the contrary, soil microorganisms of the mixed oak forest were quite insensitive to the released chemicals. The use of natural leachates allows us to suggest that chemicals released in field conditions by *mimosa* can affect the soil microbiota of native ecosystems. However, aboveground-released allelochemicals seems to be more active than allelopathic compounds exuded by roots. We conclude that the higher sensitivity of pine forest soil microbiota to allelochemicals introduced by *mimosa* can contribute to the process of invasion. We also concluded that a well-preserved complex ecosystem such as mixed oak forest could represent an effective barrier to the invasion by *mimosa*.

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Impacts of the invasive mimosa (*Acacia dealbata*) on above and belowground diversity in different native ecosystems

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The Australian tree mimosa (*Acacia dealbata* Link) is one of the most invasive *Acacia* species and has become a serious environmental problem in several parts of the world. In South Africa, there is a concern regarding the reduction in available water and faunal changes by this species (de Neergaard *et al*. 2005, Coetzee *et al*. 2007). Mimosa also reduces the presence of understory species and it can successfully establish within native forests in Chile (Fuentes-Ramírez *et al*. 2011). In the Iberian Peninsula, mimosa colonizes abandoned arable lands, transforms oak floristic composition, increases soil nutrients content and modifies the structure of the soil microbial community (Lorenzo 2010, González-Muñoz *et al*. 2012). This study was conducted to test the hypothesis that invasion by mimosa leads to changes in the composition and structure of above and belowground species communities and a decrease in biodiversity of understory plant species and soil bacteria and fungi of the invaded areas. Vegetation and soil sampling was carried out in different ecosystems: grasslands, shrublands and pine forests, in NW Spain. We differentiated three types of patch invasion status: patches with mimosa as the dominant species (invaded patches), patches with native vegetation and without mimosa ("non-invaded patches") and the transition zones between the invaded and non-invaded patches where the invasive and native vegetation are mixed ("transition patches"). In each of these areas, species richness and diversity of understory plants, soil bacteria and soil fungi were determined. Plant richness was determined as the number of plant species per square meter. Plant diversity was calculated by Shannon's index (*H'*). Richness and diversity of soil bacteria and fungi species were assessed by PCR-DGGE. Among understory vegetation, invaded patches had significant lower number of species than both non-invaded and transition patches in all ecosystems. However, there were no differences in the species diversity between patch invasion statuses. Species diversity was only affected by ecosystem type. Plant diversity was significantly higher in shrublands than in pine forests. Among soil microbes, significant differences due to invasion were only observed in grasslands, where invaded soils had a significantly higher bacterial richness and the lowest fungal richness and diversity. Our results showed that the effect of mimosa invasion on the above and belowground species varied depending on the analyzed variable and ecosystem. The impact was more important for plant species that were reduced by mimosa invasion in all ecosystems. A clear invasion effect on soil microbes was only found in the grassland where mimosa reduced soil fungi. We conclude that plant species are more sensitive to invasion by mimosa than soil microbes. We also concluded that ecosystems such as grasslands could be the most affected by the mimosa invasion.

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Ecophysiological impact of invasive *Acacia melanoxylon* R. Br. on native perennial species

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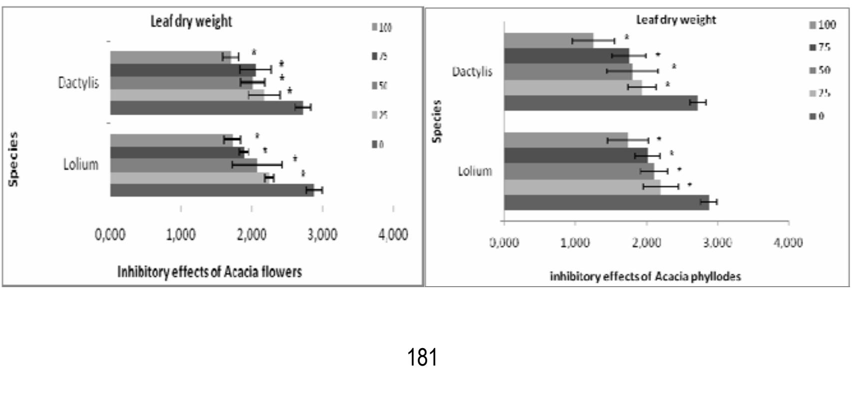
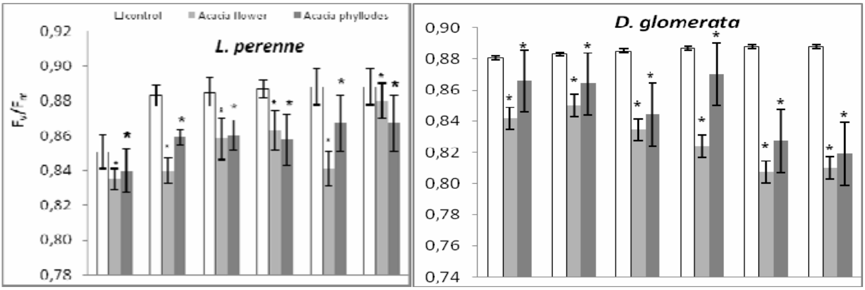
Acacia species are distributed primarily in the dry tropics and several Australian *Acacia* species have become highly invasive weeds around the world (Blakesley *et al*. 2002). *Acacia melanoxylon* R. Br. is a versatile and highly adaptive tree that currently covers a considerable area in the coastal region of the north-western Iberian Peninsula and are currently considered as invasive (Xunta de Galicia 2007). It establishes quickly in the alien environment, thereby resulting in changes to the structure and dynamics of native ecosystems. 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. 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 (100%, 75%, 50%, 25%) and distilled water was used as control. The seeds of three native plants, cocksfoot (*Dactylis glomerata*), perennial ryegrass (*Lolium perenne*), common sorrel (*Rumex acetosa*) and a general test crop lettuce (*Lactuca sativa*) were grown in perlite culture and aqueous extracts of *A. melanoxylon* (flowers and phyllodes) were applied exogenously at various concentrations. *A. melanoxylon* flowers extract (100%) inhibited the shoot length of *D. glomerata*, and *L. perenne* by 31%, and 20% of the control, respectively. Leaf and root fresh weights of *L. perenne, D. glomerata,* and *L. sativa* were reduced after treatment with acacia flowers and phyllodes extract. Leaf relative water content of *D. glomerata* and *L. perenne* was reduced by acacia flowers and phyllodes extract at all concentrations. Both extracts reduced leaf osmotic potential in *D. glomerata*, *L. perenne* and *L. sativa*. Quantum efficiency of open PSII reaction centers (F_v/F_m) and quantum yield (ΦPSII) of photosystem II were decreased in *L. perenne*, *D. glomerata*; *R. acetosa* and *L. sativa* after treatment with acacia flowers/phyllodes extract at 100% concentration. Acacia flowers and phyllodes extract (100%) inhibited the qP level during all six days in *D. glomerata*, *L. perenne*, *R. acetosa* and *L. sativa*. A significant reduction in NPQ was observed during different days in all four plant species due to Acacia flowers and phyllodes extract (100%). The $\delta\ ^{13}C$ ratios were less negative in *L. perenne*, *D. glomerata* and *L. sativa* as compared to the control. *A. melanoxylon* flowers and phyllodes extract (100%) significantly reduced leaf protein contents in *D. glomerata*, *L. perenne* and in *L. sativa*.

A)



B)



C)

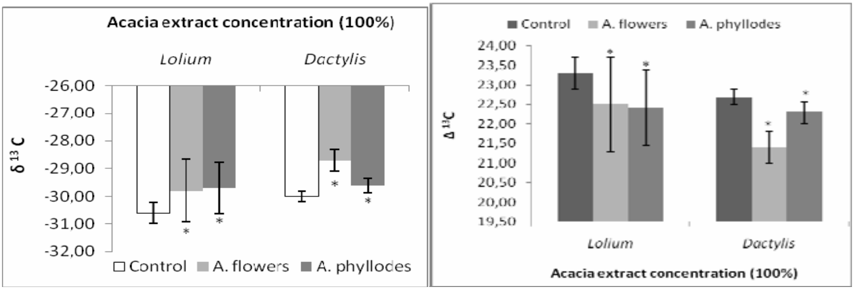


Figure 1. Effect of *Acacia melanoxylon* R. Br. on (A) leaf dry weight (g), (B) photosynthetic efficiency (Fv/Fm) and (C) carbon isotope ratios (δ ^{13}C) of native species (*Lolium perenne*, *Dactylis glomerata*).

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Alien *Acacia* invasion significantly alters the structure of pine forests and open stabilized dunes in Portugal

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Acacia spp. are among the most serious plant invaders worldwide. *Acacia longifolia*, that is native to southeastern Australia, specifically causes problems along the Portuguese coast. In this study, we evaluated the impacts of *A. longifolia* invasion on community structure, light climate, plant diversity and regeneration in pine forests and open stabilized dunes in northern and southern Portugal.
Having the growth form of a small tree or shrub, between 1 and 8 meters tall, *A. longifolia* tended to dominate the middle stratum of forests and to share dominance in the upper stratum of open dunes. The presence of *A. longifolia* was associated with a decreased canopy cover in the lower stratum of all studied habitats, and at some sites with a significantly increased Leaf Area Index (LAI) and reduced light availability in the understory. Species number and diversity were reduced by up to 50% in invaded compared to non-invaded areas. Furthermore, in forest habitats, *A. longifolia* seedlings were facilitated by proximity to an adult *A. longifolia* while the establishment and growth of native seedlings was negatively impacted (Rascher *et al*. 2011).
The replacement of drought tolerant native species by the water spending invader, *A. longifolia*, may have serious implications for ecosystem functioning, especially during the prolonged drought periods predicted to occur in Portugal in the future.

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Water and carbon cycling in a Mediterranean pine forest are substantially altered after invasion by an exotic *Acacia*

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In water limited ecosystems, where potential evapotranspiration exceeds precipitation, it is often assumed that plant invasions will not increase total ecosystem water use, since all available water is evaporated or transpired regardless of vegetation type. However, invasion by exotic species, with high water use rates, may potentially alter ecosystem water balance by reducing water available to native species, which may in turn impact carbon assimilation and productivity of co-occurring species. Here, we document the impact of invasion by an understory exotic woody species (*Acacia longifolia*) in a semi-arid Mediterranean dune Pine forest. The N_2-fixing *A. longifolia* is highly invasive in Portuguese dune and pine forest ecosystems. To quantify the effects of this understory leguminous tree on the water use and carbon fixation rates of *Pinus pinaster* we compare an invaded and a non-invaded pine stand. *Acacia longifolia* significantly altered forest structure by increasing plant density and leaf area index in the mid-stratum of the invaded forest. *Acacia longifolia* contributed significantly to transpiration in the invaded forest (up to 42%) resulting in a slight increase (9%) in stand transpiration in the invaded relative to non-invaded forest. More importantly, both water use and carbon assimilation rates of *P. pinaster* were significantly reduced in the invaded relative to non-invaded stand (see Rascher *et al*. 2011). Our study clearly shows that exotic plant invasions can have significant impacts on hydrological and carbon cycling even in water-limited semi-arid ecosystems through a repartitioning of water resources between the native and invasive species.

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Effects of invasive trees (*Ailanthus altissima* and *Robinia pseudoacacia*) on nutrients and enzymatic activity of a riparian soil

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Riparian forests of central Iberian Peninsula are widely invaded by exotic tree species as *Robinia pseudoacacia* and *Ailanthus altissima.* Both exotics have been proved to induce impacts on nutrient dynamics of some invaded soils. Rice et *al.* (2003) showed that the nitrogen-fixing *R. pseudoacacia* increased the levels of N, P, Ca and the mineralization rates in a pine-oak ecosystem. Mediterranean islands soils under *A. altissima* had higher total N, organic C and soil pH but lower CN ratio than soils under native vegetation (Vila et *al.* 2006). However it is unknown the effect of these exotic trees on riparian soils. Our aim is to assess the impact of *R. pseudoacacia* and *A. altissima* on soil nutrients (N and P), organic matter, pH, mineralization rates and phosphomonoesterase activity on invaded riparian forests. Three patches of *R. pseudoacacia* and three of *A. altissima* adjacent to the native *Populus alba* patches were selected from five different riparian forest in Central Spain (Henares River, Tajus Basin). During autumn 2011 and spring 2012, five composite soil samples were collected per patch. A total of 120 soil samples (3 species x 3 patches x 5 samples x 2 seasons) were collected, air dried and sieved before nutrient analysis (total N and P). Total nitrogen analysis of autumn samples revealed differences between soils under the exotic and the adjacent native. As expected, soils under *R. pseudoacacia* had significantly higher total N than soils under the native *P. alba*. However, the opposite was found for *A. altissima*. No significant differences were observed for total soil phosphorous between soils collected below native and exotic trees. Nitrogen increase caused by *R. pseudoacacia* may favor the spread of fast-growing exotic species to the detriment of the native species (Vitousek & Walker 1989). Further data of soil variables (e.g. enzimatic activity) will be useful to better assess the impact of these two exotic species on soils. In addition, attention has to be paid to the particular ecological context of the sites where an invasion occurs, the time of invasion and the relative abundance or density of the invasive plant, as they can also drift changes on soils (Ehrenfeld 2003).

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Eucalyptus camaldulensis invasion of riparian zones: effects on floristic diversity, stand structure and composition of native vegetation

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Effects of alien plant invaders on native ecosystems are widely acknowledged, although the evidence is mostly speculative, especially in riparian zones. We examined the effects of invasion by *Eucalyptus camaldulensis* in riparian zones on the floristic diversity, stand structure and composition of resident species in the Western Cape, South Africa. Using a gradient comparative approach, we compared the richness, diversity (*H'*) and evenness (*J*) of resident vegetation in a riparian zone under varying levels of *E. camaldulensis* percentage cover. We assessed native vegetation structural and compositional changes associated with invasion. We found that species richness, diversity and structural attributes (e.g. height, relative cover and mean basal diameter) of native species decreased consistently along the invasion gradient. However, invasion did not have an effect on native taxa evenness. *Eucalyptus camaldulensis* invasion also altered native plant species composition. Although some native species occurred in alien invaded sites, they were more abundant in uninvaded sites. Our results indicate that the invasion of *E. camaldulensis* is a threat to native riparian communities and should be prioritized for management. We also conclude that the use of a comparative observational approach applied along an invasion gradient is appropriate for the investigation of the effects of *E. camaldulensis* on resident communities. We recommend this approach for other studies assessing the effects of invasive alien tree species.

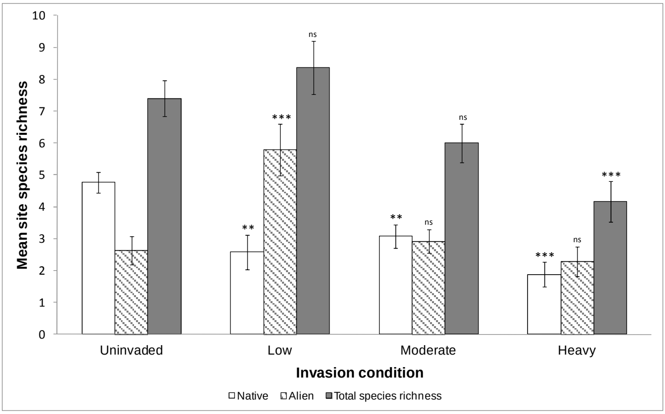

Figure 1. Native and alien plant species richness (mean ± SE) of uninvaded (n = 30) sites compared to lowly (n=19), moderately (n=25) and heavily (n=25) invaded sites along the Berg River, Western Cape province, South Africa (significant differences between uninvaded and, lowly, moderately and heavily invaded sites were tested by the non-parametric Mann Whitney U test, since all data were not normally distributed). Significance

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Does nutrient cycling differ between native and invaded riparian plant communities?

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Invasive plant species not only alter vegetation community structure and reduce species richness (Hejda *et al*. 2009) but may also influence ecosystem processes such as the cycling of carbon and key nutrients between aboveground and belowground compartments (Vanderhoeven *et al*. 2005, Ehrenfeld 2010, Vilá *et al*. 2011). A number of invasive species have spread rapidly in the UK over the last century (e.g. Pyšek & Hulme 2005) and climate change may facilitate future spread of aliens. It is therefore crucial to understand how invasive species affect exchange of nitrogen (N) and phosphorus (P) and impact upon ecosystem functioning. Here we examine how three problematic invasives (*Fallopia japonica*, *Heracleum mantegazzianum* and *Impatiens glandulifera*) alter inputs of N and P, and thus soil nutrient availability, in riparian habitats in Northern Ireland and Ireland.

Adjacent patches of invaded and native vegetation were identified on six river catchments; environmentally comparable invaded and native quadrat pairs were established. In peak growing season (June/July) 2011 we sampled living plant material, litter and soil to assess differences in N and P concentrations in aboveground and belowground compartments, associated with invasion. Paired Wilcoxon tests were used to compare invaded and native quadrats.

In our study leaf N concentrations (%) were significantly higher for *I. glandulifera* and *H. mantegazzianum* than the three most abundant plant species in native communities, whilst *F. japonica* did not differ significantly. Our results also showed that total soil N (%) was significantly greater under *H. mantegazzianum* invasion than native communities, but no difference was detected for other species. We found that potential net soil N mineralisation (i.e. the rate at which N becomes available for plant uptake) did not significantly change between invaded and native plant communities.

Soil available P (i.e. Olsen P) was significantly higher under *H. mantegazzianum* and *F. japonica* communities than native ones, indicating that these invasive species may significantly alter P cycling within ecosystems. The effects of invasives on P are less well documented and further studies need to focus more explicitly on the N and P coupling in invaded and adjacent native plant communities.

Overall our findings agree with those of previous studies (reviewed by Ehrenfeld 2010), which suggest that invasive species tend to have acquisitive plant traits, facilitating fast growth rates. However, our results also indicate that significant differences in functional traits may also occur *among* invasive plants and not only between invasive and native species, and should therefore be considered individually in their management. High variability in plant traits may suggest that the ecosystem-level impact of plant invasives may be species-specific and could only be detected using an aboveground-belowground approach where different plant and soil pools (and fluxes) are simultaneously measured through time.

Finally, our study was carried out along river corridors, which can often be eutrophic and thus the impact of invasives on soil nutrient availability may be less detectable than in resource-poor habitats; the degree of impact of invasive species to ecosystem functioning is likely habitat, as well as species, dependent.

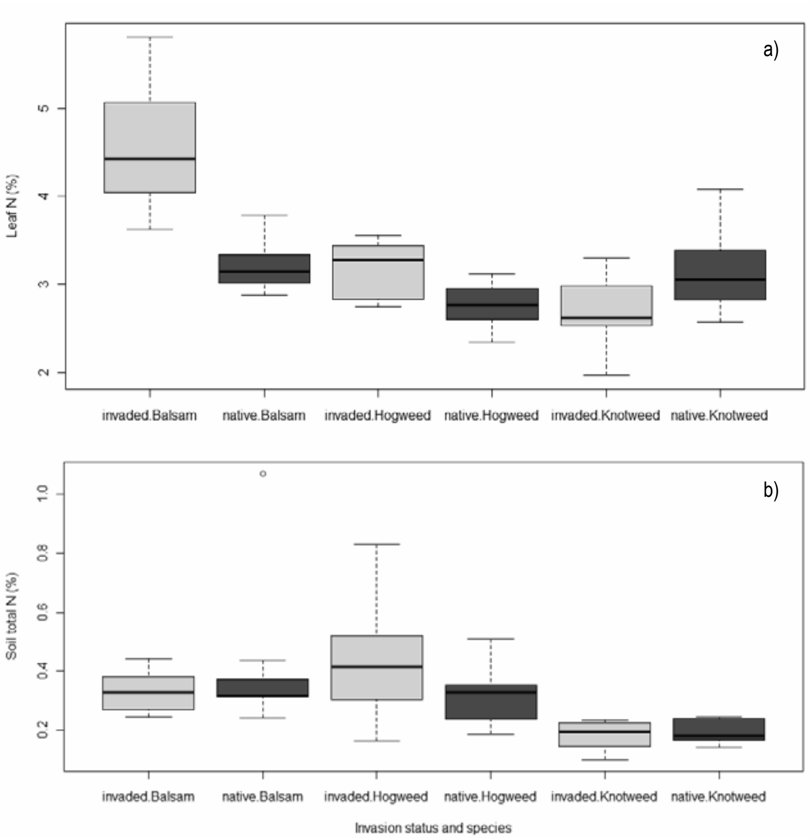

Figure 1. Comparisons of leaf N (%) (a) and soil total N (%) (b) for adjacent invaded and native plant communities in river catchments invaded by *Impatiens glandulifera* (Himalayan Balsam), *Fallopia japonica* (Japanese Knotweed) and *Heracleum mantegazzianum* (Giant Hogweed).

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Variable effects of invasive species' removal on the sexual reproduction of co-flowering native plants

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Removal of invasive species usually benefits biological diversity allowing ecosystems' recovery, but it is important to assess the functional roles that invaders may have established in their new areas before management decision. In particular, invasive plants may affect the plant-pollination interactions by changing pollinator availability and behaviour. Thus, removal of an invasive plant may have effects on pollinator community that can be latterly reflected on the reproductive success of native plants. The objective of this study was to assess the effect of removing *O. pes-caprae*, an invasive weed in the Mediterranean basin, on plant-pollinator interactions and on the reproductive success of co-flowering natives. For this, an area where this species is highly abundant was selected and the visitation rates, natural pollen loads, pollen tube growth and natural fruit set of native plants were compared in the presence of *O. pes-caprae* and after its manual removal. Our results showed a pollination network highly resilient to invasion but facilitative effects of *O. pes-caprae* on the reproductive success of co-flowering plants. Information about the possible effects of invaders on the reproductive success of natives seems crucial to assess the actual impact of aliens on plant-pollinator mutualisms.

Invasibility of relict priority habitats in the Canary Islands

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The Nature 2000 Network was established under the 1992 Habitats Directive by the European Council to assure the long-term survival of Europe's most valuable and threatened species and habitats. It is comprised of Special Areas of Conservation (SAC – ZEC in Spanish) designated by Member States under the Habitats Directive, and also incorporates Special Protection Areas (SPAs – ZEPA in Spanish), which they designate under the 1979 Birds Directive.
24 out of 168 natural habitats mentioned in the annexe I of the Habitats Directive, are present in the Canary Islands. Seagrass meadows and coastal lagoons are aquatic natural habitats, whilst 22 natural habitats left are terrestrial. Some of these are considered to be priority natural habitat types, and are conferred a special treatment in order to conservate them. In the island of Tenerife these priority natural habitat types are composed by endemic Macaronesian heaths (4050), Macaronesian laurel forests (9360), endemic forests with *Juniperus sp*. (9560) and palm groves of *Phoenix* (9370).
Since now the surface of Macaronesian laurel forests (*Pruno hixae-Lauretea novocanariensis*) as well as endemic forests with *Juniperus sp*. and palm groves of *Phoenix* (*Rhamno crenulatae-Oleetea cerasiformis, Mayteno canariensis-Juniperion canariensis, Phoenicion canariensis*) has dramatically been reduced. The main reasons for degradation of these habitats are forest exploitation, its transformation due to agricultural activity, the fragmentation of habitats, the Invasive Alien Species and fires.
The Rural Park of Anaga (Tenerife) is a natural protected area that gathers the best representation of these priority natural habitat types of the Nature 2000 Network.The aim of our research is to calculate the level of invasibility (Rejmánek 1989, Rejmánek *et al*. 2005) of the priority natural habitat types and to understand the invading potential of the major Invasive Alien Species in Rural Park of Anaga. Invasibility is defined as the vulnerability of a habitat and the associated biological community to invasion (Alpert *et al*. 2000, Davis *et al*. 2000, Milbau *et al*. 2009).
The Nature 2000 Network must guarantee the protection or, if it is necessary to establish the natural habitat types again in their natural distribution area. We consider this research project as essential for the management of this Natural Protected Area.

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Alien flora of the Czech Republic: checklist update, species diversity and invasion patterns

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A complete list of alien taxa ever recorded in the flora of the Czech Republic is presented (Pyšek *et al*. 2012) as an update of the original checklist published ten years ago (Pyšek *et al*. 2002). New data accumulated in the last decade were incorporated, and listing and status of some taxa was reassessed based on improved taxonomic knowledge. Alien flora of the Czech Republic consists of 1453 taxa, listed with information on their taxonomic position, life history, region of origin (or the mode of origin, distinguishing anecophyte and hybrid), invasive status (casual; naturalized but not invasive; invasive), residence time status (archaeophytes vs. neophytes), mode of introduction into the country (accidental, deliberate), date of the first record, niche width in the terms of the number of habitats occupied, dominance in invaded communities, and impact. Czech alien flora consists of 347 (23.9%) archaeophytes and 1106 (76.1%) neophytes. Of the total number of taxa, 983 are classified as casuals, 409 as naturalized but not invasive, and 61 as invasive. The reduction in the number of invasive taxa compared to the previous catalogue (50) is due to a more conservative approach adopted here; only taxa that currently spread are considered invasive. Casual taxa are strongly over-represented among neophytes compared to archaeophytes (76.9% vs 38.3%), and the reverse pattern holds for naturalized taxa (18.6% vs 58.5). There is no significant difference in the number of invasive species between these two groups. Of introduced neophytes, 274 taxa (24.7%) are considered vanished, i.e. no longer present in the flora, while 23% became naturalized, and 5% invasive.
In addition to the traditional classification based on introduction–naturalization–invasion continuum (Richardson *et al*. 2000), taxa were classified into 18 population groups based on their long-term trends in metapopulation dynamics in the region, current state of their populations, and link to the propagule pressure from cultivation. Mapping these population groups onto the unified framework for biological invasions introduced by Blackburn *et al*. (2011) made to possible to quantify invasion failures, and boom-and-busts, in the Czech alien flora.
Depending on inclusion criteria (whether or not extinct/vanished taxa and hybrids are considered), alien taxa ever recorded in the Czech Republic contribute 31–34% to the total country's plant diversity; taking into account only naturalized taxa, which are a permanent element of the flora, yields the figure of 12–15%. Analysis of the dates of the first record, known for 771 neophytes, indicates that alien species in the flora have been increasing at a steady pace without any distinct deceleration trend; by extrapolating these data to all 1106 neophytes recorded it is predicted that the projected number would reach 1264 in 2050. Archaeophytes are more abundant in landscapes and occupy on average a wider range of habitat types than neophytes but reach a lower cover in plant communities.

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Distribution and monitoring of selected neophytes in Luxembourg

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A series of inventories of the invasive plant species *Heracleum mantegazzianum*, *Impatiens glandulifera, Fallopia japonica*, *F. sachalinensis* and *Fallopia* ×*bohemica* have been conducted in 2006, 2007 and 2008 and the results are presented as distribution maps in a first part of the poster.
The results show that all major rivers are colonized by at least one of the studied species. The rivers Alzette and Sûre are the most affected, with four out of the five species considered, and very dense populations in many sites. *Impatiens glandulifera* is the most common of the investigated species while no occurrence of *Fallopia* ×*bohemica* was found during the survey.
In 2010 a monitoring system has been set up on 71 plots along 15 rivers across the country. Data collected in 2010 and 2011 show already slight changes in distribution of some species. This monitoring is presented in a second part of the poster.

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Early detection of alien plants in xeric Natura 2000 sites in Southern Belgium

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The Natura 2000 network consists of sites designated by the member States of the European Union, under the Habitats and Birds Directives. The set up of that network is one of the biggest challenge in nature conservation in Europe, since habitats and species for which Natura 2000 sites are designated must be maintained in a ‘favourable conservation status’. Little is known so far, however, about how Natura 2000 sites are invaded by exotics species.

Xeric habitats of high biological included in the Natura 2000 network are among the most species-rich in southern Belgium. They include calcareous grasslands, sandy meadows, dry heathlands, boxwood stands, siliceous rocks and calcareous rocks.

We randomly sampled 15% of sites in each of these six categories (with a minimum of five sites per category), with a total of 86 sites out of 470 existing sites. In each site, we recorded the presence of 63 alien plants know to develop in xeric habitats (based on Verloove (2006) and expert’s personnal observations.), and estimated species cover.

Twenty-five species were observed in xeric Natura 2000 sites. Globally, the most frequent species were *Juglans regia* (15.1 % of all sites), *Cotoneaster horizontalis* (14.0%), *Prunus serotina* (10.5%), *Robinia pseudoacacia* (8.1%), *Buddleja davidii* (7.0%), *Hieracium bauhinii* (7.0%), *Quercus rubra* (5.8%) and *Senecio inaequidens* (5.8%). Species frequency in each habitat type is presented. Globally, alien species showed low cover at the scale of the site (<5% of total area).

Our results indicate that a large panel of alien species are present in xeric Natura 2000 sites in Southern Belgium, but populations are still very limited. Early detection, coupled with further research, should help authorities to allocate financial resources to eradicate the most problematic species at early stages of invasion.

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A review on forestation activities in Turkey in the context of invasive alien plants

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One fourth of Turkey's territory is covered with forests. Due to improving forest areas, combating against erosion and desertification, and producing bioenergy and honey, forestation has been done actively. For instance almost 2 million ha area were afforested during last 4 years. Trees planted include species that are known invasive alien plants such as *Ailanthus altissima* and *Robinia pseudoacacia*. There is no study in Turkey on the distribution of invasive alien plants that have been used for forestation for long time. In addition, lack of data for possible invasiveness of those species in Turkey blocks successful awareness creating. The aim of this paper is to review the planted species, attempt to map planted invasive species and discuss activities to prevent planting future problems.

INSPECTED.NET: INvasive SPecies Evaluation, ConTrol & EDucation.NETwork

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The genus *Acacia* comprises some of the most invasive shrubs and trees which are a threat to ecosystems worldwide. At the same time, N_2-fixing *Acacia* sp. are introduced for wood production, CO_2 sequestration and soil amelioration in many countries. As “invasive ecosystem engineers”, they can alter profoundly habitat properties such as vegetation structure and nutrient cycling which finally can turn into a threat to biodiversity and ecosystem functioning.
INSPECTED.NET is a multidisciplinary exchange project between the universities of Münster (Germany), Bayreuth (Germany), Lisbon (Portugal), and Viçosa (Brazil) focusing on *Acacia* sp. invasions funded by EFP7-IRSES.
The invasive ecosystem engineer *Acacia longifolia* will be used as model species in this project. We will investigate differences in susceptibility and resilience to invasions of different ecosystems.
Our objectives are:

1. Comparison of the different ecosystems invaded by *Acacia longifolia* and other *Acacia* sp. in Portugal and Brazil
2. Assessment of impacts on biotic and abiotic resources caused by *Acacia* sp. on local scale using ecophysiological methods and field spectroscopy.
3. Assessment of the invasive potential and impacts of *Acacia* sp. on invaded ecosystems on landscape scale using hyperspectral and LiDAR remote sensing.
4. Establishing a learning and multi skilled expert network to inspect, control, evaluate and educate about plant species invasions worldwide.

We recently showed that *A. longifolia* impacts vegetation structure, light conditions and regeneration dynamics (Rascher *et al*. 2011a), water cycling (Rascher *et al*. 2011b) and nutrient cycling (Hellmann *et al*. 2011, Rascher *et al*. 2012). We were able to trace atmospheric N inputs into native plant communities using spatially resolved information of foliar stable nitrogen isotopes. By applying our innovative approach using $\delta^{15}N$ isoscapes (i.e. spatially continuous observations of variation in stable isotope ratios), we could show that the area impacted by N-addition was at least 3.5-fold greater than the physical area covered by the invader (Rascher *et al*. 2012). In 2011, we collected airborne hyperspectral and LiDAR data funded by the European Facility for Airborne Research (EUFAR). In the field, we studied *Acacia* sp. impact on vegetation structure and on ecophysiology applying field spectroscopy.
Our approach integrates information from the leaf, stand and landscape scale to trace the impact of *Acacia* sp. on ecosystem functioning. We will join expertise on plant biochemical processes and ecosystem functioning with high-resolution remote sensing and spatial modelling tools to quantify ecosystem impacts. This set up enables scaling stand-level information of alterations in biogeochemical cycles to the landscape level, opening new opportunities for understanding the spatial dimension and assessing the impact assessment of plant invasions.
Further studies will be carried out at multiple spatial scales and at different stages of invasions in Portugal and Brazil. Modelling the impact on regional scale will help prioritizing invasive species management (Thiele *et al*. 2010).

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Comparison of the vascular alien flora of wetlands in the Valencian Community, Gymnesian Islands (Spain) and Sardinia (Italy).

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This article links to previous works focused on the analysis and comparison of the alien plants of territories belonging to Sardinia and the Gymnesian Islands (Bacchetta *et al*. 2008, 2009a, 2009b). This approach has been deepened by the inclusion of continental territories, concentrated on wetlands, aquatic and riparian systems, which are particularly valuable and equally vulnerable. In the present work the alien vascular flora of the wetlands from the Valencian Community, the Gymnesian Islands and Sardinia, areas belonging to the Western Mediterranean biogeographic region, were analyzed and compared. The evaluation included the number and taxonomic composition, life forms, status (invasive, naturalized or casual), proportion between archaeophytes and neophytes, as well as the geographic origin, the introduction pathways and impacts (environmental, economic, health).
A total of 392 alien taxa were recorded in the wetlands of the entire study area, distributed in 96 families and 107 genus. The highest percentages of alien taxa correspond to Poaceae (50, 12,8%), Asteraceae (35, 8,9%) and Fabaceae (31, 7,9%) families, dominated by phanerophytes (117, 29,8%) and therophytes (105, 26,8%) life-forms. Most of the naturalized plants come from America (145, 37%), followed by Asian (55, 14%) and Mediterranean (49, 12,5%) origins.
In the Valencian wetlands, 319 taxa were detected (55 (17,2%) of them with invasive behavior), 159 (26 (16,4%) invasive) in Sardinia, 116 (24 (20,7%)) in Majorca, and 98 (23 (23,5%)) in Minorca (Figure 1). In contrast, it is striking the large proportion of casual taxa in the Valencia region (153, 48%), probably because many potential invaders are still within a pre-expansion lag period. The alien flora of the wetlands in the territories is particularly high: 47,4% of the total alien flora and 10% of the total flora for Valencia, 35% and 18,8% for Sardinia, 42,8% and 6,1% for Majorca and 41,4% and 6,5% for Minorca. These data are consistent with Genovesi (2007), who concludes that Europe is the region of the world with the highest recorded introductions in wetlands.
The three territories have only 35 taxa in common, being 160 unique to Valencia, 42 to Sardinia, 12 to Majorca and 3 to Minorca. Only 5 taxa behave as invaders in all areas studied: *Ailanthus altissima*, *Arundo donax*, *Cortaderia selloana*, *Oxalis pes-caprae* and *Symphyotrichum squamatum*. The main introduction pathway is the intentional one of ornamental plants (34% VA, 38% SA, 47% MA, 38% MI) and most of them mainly cause significant environmental impacts (55 VA, 26 SA, 24 MA, 23 MI).
A greater richness on exotic species was found in continental territories than insular ones, and the serious risk of Valencian wetlands was evident. This study confirms the particular susceptibility of European inland waters to invasions as a direct consequence of the rapid growth of transport, trade, and tourism. The results obtained allow identifying the most dangerous taxa for each territory, highlighting some absences that could help early detection of potentially dangerous plants, helping to predict where invasive plants will have their greatest impact and increasing the speed and effectiveness of management programs.

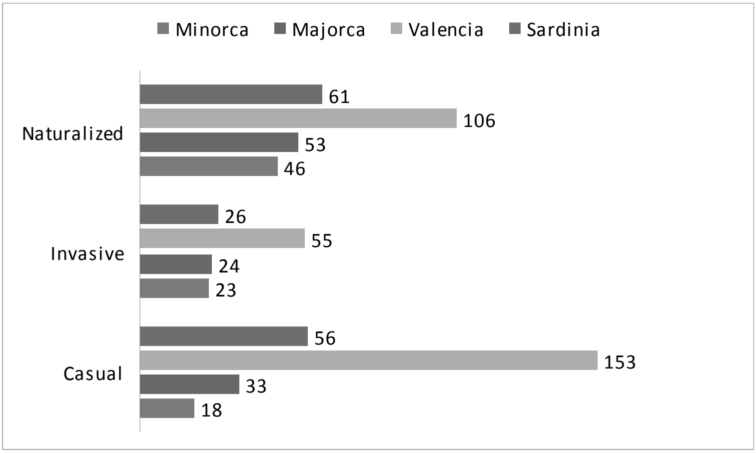

Figure 1. Distribution of alien plant species in Valencia, Sardinia, Majorca and Minorca in relation to status (invasive, naturalized or casual).

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Overview of the ongoing researches on the invasion of *Vespa velutina* var. *nigrothorax* (hym.: vespidae), the asian hornet, in Europe

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The high abundance and impact on honeybees of the Asian hornet *Vespa velutina* var. *nigrithorax* have caused great concern among French public authorities and beekeepers. The species was reported for the first time in 2005 and spread out across 50 French departments (ca. 270.000 km²) within 7 years (INPN 2012, Rome *et al*. 2012). Its arrival was reported in 2010 in Northern Spain, and in 2011 in Portugal and Belgium. Its wider expansion in Europe is soon to be expected.
We discuss here the advances of the collaborative research project initiated in 2008 in France.
1- The potential invasion risk of the species was assessed using modeling tools of climatic suitability Villemant et al. 2011). Interestingly, the potential distribution of *V. v. nigrithorax* matches the current distribution of another invasive social wasp, the German yellow jacket, *Vespula germanica* (Beggs *et al*. 2011).
2- Apart from reported damages on hives, little is known on the biology of *V. velutina* throughout its native Asian range. In the invaded range (Figure 1), the impact of *V. v. nigrithorax* on the diversity and biomass of the invertebrate fauna is under study. Preliminary results reported a diversified diet varying among seasons and habitat types.
3- The genetic variability between individuals of *V. v. nigrithorax* from France and Asia was assessed in order to describe the history of its invasion. The analysis has evidenced a low variability among the invasive population, which indicates a single introduction of one or more queens. The sampling of specimens in France and in the area of origin has been extended to confirm this hypothesis and the most probable area of origin (Arca 2012).

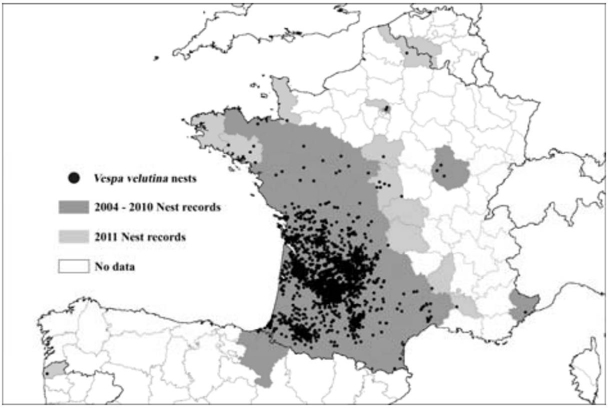

Figure 1. *Vespa velutina* nest records from 2004 to 2011: Data obtained from public records and individually validated through the INPN databases (INPN, 2012), including all nests found between 2004 and 2011.

Given the potential economic and biological impact of *V. v. nigrithorax*, a better understanding of its invasion dynamics is necessary to predict regions at risk, hence to help with planning dedicated control measures, a prerequisite for replacing the reactive nature of current solutions with a proactive, predictive approach.

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The invasive asian hornet *Vespa velutina* Lepeletier in the Basque Country (Northern Spain). The History of a recent invasion.

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The asian hornet *Vespa velutina* Lepeletier, 1836 (Hymenoptera: Vespidae) is a specialized predator of honeybee foragers widely distributed across Asia: China (South and Central provinces, Hong Kong), India (northeast), Indonesia (Java, Sumatra, South of Sulawesi and Lesser Sunda Islands), Malasia (Peninsula) and Taiwan (Archer 1989). Its presence in Europe was first detected in 2005, after finding one exemplar at Nérac, Lot-et-Garonne, France. Specifically, this species belonged to the subspecies *V. velutina nigrithorax* du Buysson, 1805. Since then, the insect spread rapidly throughout the southwest of France, and nowadays *V. velutina* is well established across the southwestern part of France (Villemant *et al*. 2008).

Concerning the Spanish mainland, a female worker of *V. velutina* was found in the locality of Amaiur, province of Navarre (northern Spain) in August 2010 (Castro & Pagola Carte 2010), and more reports were produced in different localities of eastern Guipuzcoa (Basque Country) during October 2010 (Figure 1) (López *et al*. 2011). Since then, 67 nests have been retired along Guipuzcoa province to date (Figure 2). Recently, *V. velutina* has been found in Oñati (Guipuzcoa), a locality close to Biscay province, clearly indicating that the hornet is present across the Basque Country. Although there are no records from the other provinces of the Basque Country (Biscay and Alava), it is likely that its presence might be reported in these territories in the near future.

Vespa velutina nigrithorax is often confused with *V. crabro germana* Christ, 1791, a wasp species commonly found in mainland Spain. However, the head of *V. velutina* is black with an orange frons and it is characterized by a completely black thorax, whereas. Differences can also be observed on the abdomen, with *V. velutina* showing terga II–III edged with a thin yellow band and the fourth tergite with a wide orange band. Little is known about the biology of *V. velutina* in Europe.

Concerning its life cycle, it has been observed in France that mated queens emerge from their overwintering period in February–March and each one begins the construction of the embryo nest. First workers emerge in May and mature individuals emerge in autumn. Finally, the colony stops its activities and dies at the onset of winter (November–December). Nests are large and round, and built at the tops of trees or low down in bushes. Although in France nests were typically constructed on high trees (oaks, poplars, acacias, conifers) (Villemant *et al*. 2008), it seems that their presence in urban areas has recently increased. *Vespa velutina* is generalist predator. Its diet mainly consists of other hymenoptera and diptera, but also other includes other insect orders (Hemiptera, Orthoptera), spiders, fruits and vertebrate flesh. Regarding human health, although there have been no severe attacks reported on humans in France, it is considered to be one of the most aggressive hornets in its area of origin (Barthelemy 2008).

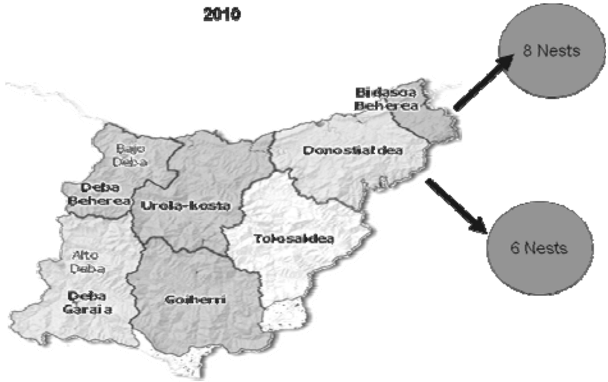

Figure 1. Nests located in Guipuzcoa province in 2010

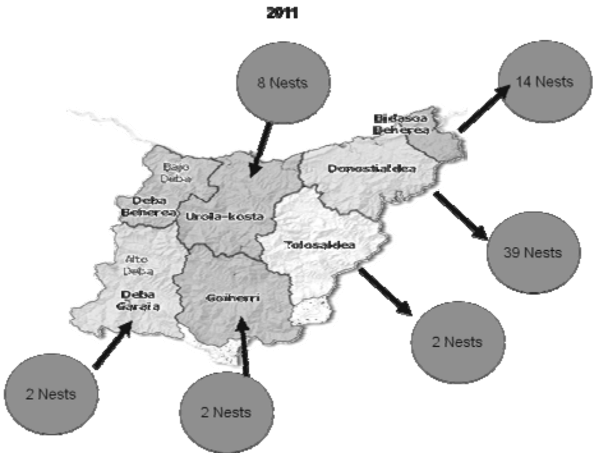

Figure 2. Nest located in Guipuzcoa province in 2011

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Cryptotermes brevis (Wlk) (Isoptera: Kalotermitidae): A new termite problem in the Iberian Peninsula

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Cryptotermes brevis (Walker, 1853) is a very ubiquitous termite species spread worldwide from its original region in Chile and Peru (Scheffrahn *et al*. 2009). This termite is able to survive with very low moisture content in structural timber, furniture or decorative wood products, where they live in small colonies. The infestation of new structures is achieved by means of seasonal swarms. The inadvertently transport of wood goods by human activity promotes their dissemination. The species is found in almost 70 countries in over all continents (Scheffrahn *et al*. 2009).

C. brevis was cited is Spain (Anon. 1980) in the Mediterranean coast (close to Valencia) based on a reference by Torres-Juan. The presence in Iberian Peninsula was recently confirmed in Lisbon (Nunes 2008) and Barcelona (Nunes *et al*. 2010).

Since the first finding in Barcelona (2005) made by Ibertrac S.L., 14 new damaged buildings have been found: 2006 (1), 2007 (1), 2008 (3), 2009 (2), 2010 (3), 2011 (4). The distance between the two farthest buildings is more than 5 km. *C. brevis* damages are similar to those caused by *Kalotermes flavicollis* (Fabricius, 1792), and probably many of treatments against this species could be caused by *C. brevis* and the problem would be stronger than we can expect. Recently a new case has been found in Alicante (Mora 2011).

The aim of this contribution has been to analyze the evolution of this pest in Iberian Peninsula, mainly in Barcelona, and to propose possible ways for treatment and control.

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Reproductive biology of the alien Korean bait-worm, *Perinereis vancaurica tetradentata* (Annelida: Nereididae), from the Mar Menor Lagoon (Western Mediterranean)

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In the Mediterranean Sea the rate of biological invasions has increased in recent decades. Currently, the number of non-indigenous marine species recorded is roughly 500, while the biological and ecological impact of most of them is almost unknown (Galil 2007). Along with other vectors of introduction, bait-worm trading has been shown to be a potential source of invasive species (Haska *et al*. 2012). In the Mediterranean Sea, many species of non-native bait-worms are imported. In the present study, we report on the existence in the Western Mediterranean, Southern Spain, of a reproductively active population of one of these commercially introduced bait- worms, the Korean ragworm *Perinereis vancaurica tetradentata* Imajima, 1972 (Annelida: Nereididae) providing further evidence for the invasive potential of commercially introduced bait-worms. The diagnostic features of the aforementioned species are associated with the arrangement of paragnths on the eversible pharynx, viz.: two rows of 16-17 paragnaths in a crescent in Area II and a transverse cluster of 41-50 paragnaths arranged in a rectangle (no lateral groups) in Area III. This is the first record of this species establishing a population outside its native range of the NW-Pacific.

Specimens of *P. v. tetradentata* were collected alive from the intertidal soft bottoms of the Mar Menor Lagoon in March 2012 and brought to the laboratory for identification and to carry out a preliminary study of their reproductive biology. The populations in the Mar Menor showed a maximum average density of 7.36 specimens/m² and occurred together with a high biodiversity of mollusc bivalves, most notably other non-native species like the Lessepsian cockle *Fulvia fragilis* (Forsskål in Niebuhr, 1775). Collected specimens were 158.39 ±13.42mm long and had 129 to 173 chaetigers. The mean body width (10th chaetiger) was 5.3 ±1.22 mm. The population had a female biased sex ratio, with 10 times more females than males, and most of the collected specimens (ca. 70%) were metamorphosed forms exhibiting epitokous parapodial transformations from 30th up to the 70-100th chaetiger. The extremely low male proportion did not allow testing for the existence of sexual size dimorphism. However, sexual dimorphism associated with the epitokous parapodia could be observed. In metamorphosed females, three epitokous stages could be recognized: incipient, climax and involution. Yet, except for the latter stage, a clear correlation of the epitokous stages with certain phases of oogenesis could not be established, probably because within the same female individual the oogenesis was asynchronic and not all eggs reached their full mature size before egg-release. In *P. v. tetradentata*, egg fertilization occurred internally in the female coelom and females released zygotes and metatrochophores through openings of their body walls. Females incubated gelatinous egg masses containing embryos and larvae but also immature oocytes and eleocytes, which may have a nutritive value for the developing embryos. In the egg-masses, also symbiotic ciliate protozoa (*Euplotes* sp.) were observed feeding on the oocytes and embryos vitellus-pellets. If introduced together with *P. v. tetradentata*, these ciliates may be a potential risk for native beach-worms.

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Palaemon elegans Rathke 1837 – an alien species in the Gulf of Gdansk - what are the costs and benefits of its presence?

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In general, the presence of alien species means threat to native flora and fauna. However, when it appears in environment, it does not mean only negative consequences. It can be significant for the food web and become a valuable element in the human economic system.

Palaemon elegans Rathke 1837 is an alien species in the Baltic Sea. For the first time it was observed in the Gulf of Gdansk (Southern Baltic) in late 2000 and 2001. In many parts of the Baltic coastal zone occurs in large numbers, it does not have a negative impact on native species, including the family *Palaemonidae*.

Hydroxyproline is an amino acid, characteristic of collagen - a protein which plays an essential function in living organisms and is used extensively in various industries. In the research, a method based on the determination of condensation products of the oxidation of hydroxyproline with p-dimethylaminobenzaldehyde (PABA) was used. Hydroxyproline content research, performed on individuals of *P. elegans*, confirmed the presence of collagen in their bodies. The content of studied amino acid had ranged from 1.14 to 2.22 µg/100 mg DW (dry weight), which was after conversion average 13.64 ± 2.47 µg/100 mg DW of collagen. In comparison to males, *P. elegans* females had a higher content of hydroxyproline, and thus the collagen ($P < 0.05$). The seasonal variations of the protein level in *P. elegans* were observed, but they were not significant for statistics ($P > 0.05$).

Due to the large number of *P. elegans* in the Gulf of Gdansk and relatively high content of hydroxyproline in the tissues, this species may be a potential source of collagen.

Effect of the invasive polychaete *Marenzelleria* spp. on benthic processes and meiobenthos in shallow sandy sediments of the Southern Baltic Sea – preliminary results

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The North American polychaete *Marenzelleria* spp. was observed in the Baltic Sea for the first time in 1985. Subsequently, this species has spread effectively over the whole area and became the most dynamically developing invader in the Baltic. *Marenzelleria* spp. buries deeper than the majority of native species and has the potential to affect the biogeochemical processes through deep-reaching bioturbation but its effect on the interstitial fauna remains unknown.

Microcosm laboratory experiments focused on the impact of this invasive polychaete on biogeochemical processes and meiobenthic community with emphasis on free-living nematodes were performed at two study sites: the very shallow, semi-enclosed and species-poor Vistula Lagoon and the more exposed and species richer Puck Bay (Southern Baltic Sea). It was hypothesized that the deep burrowing invasive polychaete inhabiting sediment layers not hitherto affected by the native fauna significantly affects both sediment processes and meiobenthic community structure and diversity. In the Puck Bay the effect of *Marenzelleria* spp. was compared to the effect of the native co-occuring polychaete *Hediste diversicolor*.

Preliminary results have shown that *Marenzelleria* spp. ventilated the sediment, stimulated organic mineralization, affected vertical profiles of pore water nutrients concentrations and processes at the sediment-water interface. At both study sites, *Marenzelleria* spp. reduced pore water ammonium concentrations and stimulated excretion of ammonium from the sediment to the water column. Total organic carbon and total nitrogen contents in the sediment were reduced at the presence of this polychaete compared to the defaunated control. The effect of *Marenzelleria* spp. differed, however, from the effect of the native polychaete *Hediste diversicolor* which affected sediment processes more powerfully.

Marenzelleria spp. has not influenced the total meiobenthic numbers indicating no mortality due to the physical sediment disturbance or predation by the polychaete. *Marenzelleria* spp. has, however, facilitated meiobenthic, particularly nematode, penetration of deeper sediment layers when compared to defaunated sediment. This indicates that nematodes were attracted by new niches available due to the activity of the bioturbator. Surprisingly, nor the nematode community structure or diversity were affected by *Marenzelleria* in the Vistula Lagoon even at very high densities of the worm. This effect of *Marenzelleria* on meiobenthos in the Vistula Lagoon differs from effects of other polychaetes observed in other benthic environments. This suggests that either the overall effect of *Marenzelleria* spp. on meiobenthos is very weak or that nematode community in species-poor system is structured more by severe chemical environment than by the presence of the invasive bioturbator.

Ponto-Caspian gammarids – new species in the Gulf of Gdańsk (southern Baltic Sea)

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Non-indigenous gammarid species: *Pontogammarus robustoides* (G.O.Sars, 1894), *Obesogammarus crassus* (G.O. Sars, 1894), *Dikerogammarus haemobaphes* (Eichwald, 1841) and *Dikerogammarus villosus* (Sowinsky, 1894) are present in the Gulf of Gdańsk (southern Baltic Sea). These species reached the Gulf of Gdańsk by 2010 near the point where the River Vistula flows into the Baltic Sea, and become constituents of the amphipods in shallow bottom.
All the gammarid species found are of Ponto-Caspian origin. They have been able to move across Europe along rivers and canals, and inhabit reservoirs and drainage systems in the vicinity of such waterways. *D. villosus* is the latest gammarid species to have colonized Poland.
The floods that afflicted Poland in May and June 2010 could have had a significant influence, intensifying as they did the inflow of water from the Vistula into the Gulf of Gdańsk. This could have accelerated the arrival of individuals of these species. The water salinity at the sampling stations was 5.8 – 6.1 PSU. The possible invasion of non-native gammarids may have important consequences for the benthic fauna communities in the Gulf of Gdańsk.

Potential impact of the American crab *Rhithropanopeus harrisii* on other macroinvertebrates in the coastal Baltic waters

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The American mud crab *Rhithropanopeus harrisii* (Gould, 1841) has been introduced to the Baltic Sea in early 1950s, but its patchy abundance was restricted mostly to adjacent reservoirs such as lagoons and estuaries. In the last few years this crab has become also a stable component of the benthic communities in the coastal Baltic waters like the Gulf of Gdańsk (Poland). Being an opportunistic omnivore, equipped with massive claws, this non-native crustacean (max. carapace width 22 mm) may significantly affect co-existing species through trophic interactions, especially when occurring in large abundances. Laboratory experiments showed that the American mud crab prefers animal diet to plant one. Studies concerning stomach repletion index (SRI) and stomach content of *R. harrisii* (n=72) from the Gulf of Gdańsk demonstrated the presence of remains belonging to *Amphipoda*, *Ostracoda*, *Polychaeta*, *Gastropoda* and *Bivalvia*. Neither the sex nor the size of an individual crab had a significant influence on the SRI or on the diversity of the found food items. Laboratory studies indicate that in the coastal Baltic waters *R. harrisii* can affect populations of bivalves, like *Mya arenaria*, *Macoma balthica*, *Mytilus trossulus*, *Cerastoderma glaucum* either through predation or as well as through damaging (crushing) their shells. The observed American mud crab (carapace width 14.1 ± 1.3 mm, major claw length 11.8 ± 1.5 mm) attacks also larger *M. trossulus* (shell length 24.5–50.6 mm) by chipping away at the shell margin with the large crusher chela or through the insertion of a chela between the shell margins in order to prevent its closure. Although *R. harrisii* is able to open large blue mussels, it is more effective in predating small sized individuals of < 10 mm shell length. Obtained data might be helpful in assessment of the potential ecologic impacts of the American mud crab on local communities.

How invasive alien species are changing ecological quality status of aquatic ecosystems?

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During the last decades introduced species have become a major concern in ecology and aquatic nature conservation. Biological invasions can have a variety of cascading effects in the aquatic environment including interspecific competition, predation, disturbance, and the alterations in energy flow and in the overall equilibrium of species in the invaded community. The aim of the current study was to review the documented evidence of aquatic invasive species (AIS) impacts on water quality elements. In the study, 16 indicators of biological, hydromorphological, physico-chemical, water quality elements (as described by the Water Framework Directive (WFD), EC 2000) were considered. For the analysis 36 inland and marine invasive species listed in the "100 most invasive species in Europe" (DAISIE 2009) were selected. After the extensive literature search using Google Scholar service, the information on AIS impacts was retrieved. For the further analysis only reliable well-documented facts from either observational or experimental studies were considered. In total 152 scientific publications were reviewed. Our analysis shows that most of the water quality parameters used in the WFD can be modified by invasive species. The documented evidence of influence on any of the parameters was obtained for 32 of the selected species. In total 280 cases of impacts on biological, physico-chemical and hydro- morphological quality elements were identified. As reflected in the literature, the mostly affected are biological quality elements (particularly fish indicator). The major part of the impacts on quality elements was reported for invasive fish, macrofauna and aquatic plants. There was only one element (salinity) with no documented evidence of possible influence by invasive species. Invasive species are able to cause changes in ecological status of a waterbody. All levels and processes within an aquatic ecosystem can be modified by presence and functioning of an invasive species. The impacts of AIS should be considered while assessing ecological status of a waterbody and implementing water quality improvement tools and programs.

First registration of *Trichodina domerguei* (Ciliophora, Trichonidae) from Ponto-Caspian gobies in Poland

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The purpose of this study was to investigate the geographical distribution of trichodinid parasites in freshwater and estuarine gobies (Pisces: Gobiidae) in the polish part of Central migration corridor. Parasitological study of non-indigenous Ponto-Caspian gobies was conducted in June-July 2011. Four species of invaders (monkey goby *Neogobius fluviatilis*, racer goby *N. gymnotrachelus*, round goby *N. melanostomus* and western tubenose goby *Proterorhinus semilunaris*) were investigated. Gobies were sampled on 16 locations including Polish Part of Bug River, the lower rich of Narew River, Wloclawek Reservoir, the lower part of Vistula River, and fragment of Vistula Estuary, including Dead Vistula.
A ciliate *Trichodina domerguei* Wallengren, 1897 was discovered from the sampling sites. The ciliate was isolated from the gills and the fins of all four species of Ponto-Caspian gobies, investigated in Poland. From several to hundred specimens of *T. domerguei* was recorded on one fish. Prevalence varied depending on the host species and region of dwelling. Totally it was highest in *N. fluviatilis* (62,5 % in Bug River, 74,1 % in lower rich of Narew River). Prevalence of *T. domerguei* in *P. semilunaris* had relatively low value in Włocławek Reservoir (14,3 %) and it was 2,5 times higher in Vistula Estuary (33,3 %). *N. melanostomus* and *N. gymnotrachelus* were the least contaminated by *T. domerguei*. The ciliate was found in only in 5,3 % of dissected round goby specimens exclusively in Lower Vistula. Prevalence of *T. domerguei* in racer goby was 5,9 % in Bug River, 12,5 % in lower rich of Narew River and 6,3 % in Lower Vistula.
T. domerguei is one of the most widely distributed trichodinids. The ciliate was registered in about 35 both marine and freshwater fish including gobies, and some amphibian species from freshwater and marine sites (Rivers and Lakes of Russia, Georgia, Estonia, Lithuania, Finland, Sweden, Poland, Czech Republic, Slovakia, Hungary, Romania, Germany, Belgium, France, United Kingdom, USA; the Baltic, White, Black, Azov, Caspian, Aral and Japan Seas).The present study firstly recorded ability of *T. domerguei* in Ponto-Caspian gobies, inhabiting the polish part of Central corridor of Trans-European migration of hydrobionts.
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The outspread of *Anabaena bergii* and related taxa in European freshwaters

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Anabaena bergii Ostenfeld and related smaller in size morphospecies identified under different species names (*A. bergii* var. *minor* Kisselev, *A. bergii* f. *minor* (Kisselev) Kossinskaya, *A. bergii* var. *limnetica, A. minderi*) belong to the *Anabaena*-like cluster B according to Komárek (2010). Group include planktic filamentous cyanobacteria characterised by solitary metameric trichomes slightly narrowed towards the ends, with elongated akinetes in a paraheterocytic position.
A. bergii Ostenfeld and smaller in size *A. bergii* var. *minor* Kisseliov are native to the Ponto-Caspian region and was described from the Aral Sea. The species belonging to a group of morphologically similar to *Anabaena begii* taxa generally occur in the saline-brackish environments of Ponto-Caspian region including Caspian and Black Seas, Lake Issyk-Kul, relict lakes and outside the area (Bardawil Lagoon, Saaler Boden, Slatina Pond, Lake Phoosna). On the other hand, these morphospecies were recorded in freshwaters of Austria, Belarus, the Czech Republic, Egypt, Germany, Slovakia, Turkey, Ukraine and Senegal also. *A. bergii* is considered as alien cyanobacteria in freshwaters of Slovakia, Germany and the Czech Republic (Hindák & Hindákova 2001, Stüken *et al*. 2006; Kastovsky *et al*. 2010).
Up to date, *A. minderi, A. bergii* and its varieties are found in more than 70 water bodies varying from deep saline seas to shallow freshwater ponds. Morphospecies often tend to appear in small (area less than 5 km^2) and relatively shallow water basins (mean depth <5 m). In 2008, *A. bergii* var. *limnetica* was first time observed in a Lithuanian hypertrophic lake, which is the northernmost point of *A. bergii* and its varieties distribution. In this study species morphological characters will be discussed as important aspects for practical use and identification of natural populations.

Effects of the invasive *Gonyostomum semen* (Raphidophyceae) on the taxonomic structure of plankton assemblages in Lithuanian lakes

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Reports on the raphidophycean flagellate *Gonyostomum semen* (Ehrenb.) Diesing blooms in the humic lakes have increased over the past two decades with a tendency towards a wider distribution of the algae in non-humic lakes occupying new habitats and areas. It is a nuisance species as it causes itching and allergic reactions to people swimming in the lakes and can be viewed as a potential risk for environmental health.

Detailed studies on *G. semen* in Lithuania freshwaters started from 2008. Up to now it occurres in 50 lakes from different parts of Lithuania. Mainly the species was found from the small humic, slightly acidic to slightly alkaline (pH 4.28–7.76), and low conductivity (11–34, rarely over 100 $\mu S\ cm^{-1}$) lakes. It is likely that in *Gonyostomum* dominated lakes this species induced changes in the structure of plankton assemblages. The aim of the study was to present the characteristics of physico-chemical and biotic parameters of the lakes developed in the process of *G. semen* succession. Species appeared from July to September and reached its seasonal biomass maximum usually in late summer and early autumn. It occurred with rather high abundance, from 3 to 822 thous. cells/l and biomass 0.03–32.7 mg/l. The highest G*. semen* productivity was assessed in the lakes of the northern part of Lithuania. *Gonyostomum* heavy bloom reaching up to 0.82 g/l was observed in the Lake Natalka.

The limited development of phytoplankton was observed in the lakes resulted most probably from the compensatory activity of *G. semen.* Principal Component Analysis was performed for the comparison of plankton algal assemblages. Four lakes groups were distinguished. In the first group, *G. semen* biomass comprised more than 50 % of total phytoplankton biomass. Accompanying species were *Peridinium* spp., *Ceratium*. In the second group, raphidophytes and chlorophytes largely *Botryococcus* cf. *terribilis*, *Staurodesmus cuspidatus* dominated and constituted 25–45 % of the total phytoplankton biomass. In the remaining lakes, *Gonyostomum* biomass was less than 15 %, and cyanobacteria, chrysophytes or chlorophytes prevailed. Small chrysophytes, *Dinobryon divergens*, blue-greens *Chroococcus minutus* and *Merismopedia tenuissima*, greens *Stichococcus* sp. and *Cosmarium* spp. dominated.

The studies concerning zooplankton populations vulnerability to raphidophytes development patterns are continuing. *G. semen* formed specific zooplankton assemblages. Further studies are required to explain or predict the specific factors driving phyto- and zooplankton interactions.

Impact of parasites on populations

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Text of the abstract: Parasites and pathogens are increasingly recognized as key players in the maintenance of biodiversity (Hudson *et al*. 2006), the outcome of biological invasions (Dunn 2009) However, we still lack sound empirical and theoretical principles to explain and predict how parasitism at the levels of individuals and single populations scales up to communities (Lafferty *et al*. 2008). Parasites influence intraspecific and interspecific interactions both through density-mediated effects and through via direct changes in interaction strengths, for instance, altering the hosts competitive or predatory abilities.

We are exploring such parasite induced changes in host-host interaction strengths in a freshwater invasion. In freshwaters in N. Ireland, UK, invasion by the amphipod *G. pulex* leads to extinction of the native *G duebeni* and shifts in macroinvertebrate abudance and biodiversity. The native *Gammarus duebeni celticus* and the invasive species *Gammarus pulex* interact via competition (predation on a shared pool of macroinvertebrates), cannibalism, Intraguild predation, predation from top predators (fish) and parasitism.

We investigate the impact of two native parasite species on cannibalistic and predatory behaviour of invasive and native amphipods. Surprisingly, we find that G pulex infected by the acanthocephalan parasite *Echinorhynchus truttae* are more cannibalistic than are uninfected individuals. Similarly, infection of the native *G duebeni* by a microsporidian parasite increases its rate of cannibalism. A mathematical model predicts that cannibalism can be important in maintenance of a stage structured populations, etc. However, when offered the choice of *G. pulex* vs G duebeni, the native G duebeni prefers to prey upon the invasive species thereby avoiding the risk of cannibalism from eating infected conspecifics. By altering the cannibalistic and predatory tendencies of the host, parasites can affect the impact of the invader on the recipient community.

Distribution, abundance and growth of the Manila clam *Ruditapes philippinarum* in the Tagus estuary (Portugal)

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The introduction of exotic marine species into habitats outside their native geographical range is a side-effect of trade globalization. Several of these non-native species produce significant impacts over ecosystem structure and functioning of colonized areas, including spatial and food competition and predation of native species. The Manila clam *Ruditapes philippinarum* (Adams & Reeve, 1850), native from the Asian Pacific, is well known for its ability to colonize and invade new habitats. It was firstly introduced in Europe in the 1980´s decade, and it is believed to have reached Portugal more than ten years ago. Although there are no specific studies on the population state of this species and its impacts in the Tagus estuary, a significant increase on fisheries has been observed in the last years, indicating a population increase. The major objectives of this study were (i) to assess the spatial distribution of *R. philippinarum* in the Tagus estuary and associated environmental conditions and (ii) to determine its growth in different areas of the estuary.

Our results showed that the Manila clam is consistently distributed in the estuary and occupies the same habitat types as *R. decussatus*, *Cerastoderma glaucum* (Poiret, 1789) and *Solen marginatus* Pulteney, 1799, namely mesohaline to polyhaline, muddy subtidal areas. The growth parameters calculated based on the von Bertalanffy equation were consistent with what was previously found for the same species (L_∞ = 65.2; k = 0.34; t0 = 0.93). The use of different age estimation approaches indicated that the acetate peel technique is the most suitable for this species.

The present study showed a clear depletion of the native clam in the Tagus estuary and a simultaneous increase of the population of *R. philippinarum*, indicating that the exotic species may be outcompeting the native clam populations. Further work should be undertaken to evaluate the impact of the introduction of this species in Portuguese aquatic systems and to prevent the complete eradication of the indigenous clam.

Expansion of the exotic unionid *Anodonta woodiana* in northeast Catalonia (Spain)

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In the northeast Catalonia, 4 native unionid species have been cited: *Potomida littoralis* (Cuvier, 1798), *Unio mancus* (Lamarck, 1819), *Unio ravoisieri* (Deshayes, 1847), and *Anodonta anatina* (L, 1758). Recently the exotic *Anodonta woodiana* (Lea, 1834), has been cited on Ter and Fluvià rivers. Between 1995 and 2010, several specific surveys were carried out, always below the Pasteral dam, both in the Ter river and in several of its tributaries, including Lake Banyoles. Moreover, during 2010 a thorough freshwater bivalves prospection campaign was performed in the alluvial plain of lower Ter, including the river and secondary water masses, mainly irrigation channels associated with the traditional system of agricultural irrigation. The prospections were done by manually on the river bed bottom. All over 2010, a total of 50 sampling stations were surveyed in this alluvial plain.
Evidence shows that all native species in the basin are still present, though their general conservation status is precarious, with populations intensely fragmented, and densities often low and heavily aged for lack of recruitment. This situation is clearly attributable to the severe rarefaction of native fish species, in some areas even completely inexistent.
By contrast, the exotic *A. woodiana* is expanding and occupies already the whole alluvial plain and the lower course of the Ter river, where it is very abundant. Also, A. woodiana presents a well-structured global population in the alluvial plain of Ter River; a regular recruitment can be observed thanks to the fact that several exotic fish species, present and abundant in the area, are potential hosts to them.
This exotic unionoid appeared in 36 (72 %) of the surveyed localities, and was present in all the types of bodies of water that were surveyed. In 8 (16 %) of these localities it was the only unionoid found, while it was only absent in a small part of the localities were other unionoid were present (3, 6 %). Specimens found alive (1390) constituted the 73 % of the total of alive unionoids collected during the intensive surveying campaign, the species being quantitatively dominant in the whole of the alluvial plain. Therefore, it is the most spread and abundant unionoid species at present, often with very high densities. It presents a continuous distribution in the lower Ter river basin, as well as in the main irrigation canals.

Trophic impacts of two invasive decapods on freshwater communities

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Invasive species are a major cause of biodiversity loss worldwide. The Chinese mitten crab (*Eriocheir sinensis*) and signal crayfish (*Pacifastacus leniusculus*) are large aquatic decapods which since the 1950s have developed worldwide introduced distributions, and are both listed within the top 100 worst invaders. Predicting the impacts of invaders on communities is crucial to drive forward policy and direct strategic control measures to minimise loss of native biodiversity.
Range expansion means that Signal crayfish and Chinese mitten crab increasingly co-occur in freshwater habitats, yet little is understood about how these two apparently opportunistic omnivores may interact to impact existing communities.
We used a variety of approaches including mesocosms, prey-choice trials, gut contents and stable isotope analyses to investigate trophic impacts of signal crayfish and Chinese mitten crab on benthic invertebrates and the eggs of several coarse fish species. We compare prey preferences of these two invasive predators, and use predatory functional responses to compare their predatory impact on key prey items including keystone shredders in the ecosystem and economically important fish.

Claw strength and blue mussel *Mytilus trossulus* size selection by Chinese mitten crab *Eriocheir sinensis*

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The Chinese mitten crab *Eriocheir sinensis* (H. Milne Edwards, 1853) is one of non-native species which have appeared as the result of human activity in European waters. This species is listed among the hundred world's worst alien invasive species due to many negative ecological and economic consequences it causes. Due to the large size and its mass occurrence this opportunistic omnivore might be the most serious threat to local biodiversity, mainly through the trophic interactions with other species. Although *E. sinensis* became more abundant in the coastal Baltic waters since several years, still little is known about it.
We performed a set of laboratory experiments (T = 15 ^{o}C, S = 7) to study the claw strength and the size selective consumption of Chinese mitten crabs (mean carapace width 61.81 ± 7.85 mm) on blue mussel *Mytilus trossulus* with shell lengths ranging from 11 to 40 mm. Claw strengths of *E. sinensis* varied from 1.50 to 20.43 N (mean 8.51 ± 5.93 N) and were significantly correlated with the carapace width (P < 0.05; R^2 = 0.50). A single crab consumed from 5 till 15 mussels of shell length 11to 40 mm within 24 hours. Although the studied mitten crabs were characterized by a claw opening that would allow to crush shells of larger mussels (ca. 45 mm in length) they selected at first the smallest individuals of 11 to 20 mm in length. They seem to be a more profitable prey due to the reduced cost of handling as well as a risk of chelal damage. *E. sinensis* also crushed blue mussel shells without later consumption in order to exercise their chelae.

Parasites of an alien fish spreading in Europe based on long-term observation in the Włocławek Reservoir on the lower Vistula River in Poland

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In the area of the Włocławek Reservoir on the lower Vistula River, parasitological observations of an alien fish (three Ponto-Caspian and one Asian species) have been regularly made since 2006. Occasional examination of chosen species of natives (European perch *Perca fluviatilis*, Crucian carp *Carassius carassius*, three-spined stickleback *Gasterosteus aculeatua* and ruffe *Gymnocephalus cernua*) supports this study. To date, more than 1,000 fish caught in different seasons have been studied (including 800 specimens of aliens: monkey goby *Neogobius fluviatilis*, racer goby *Babca gymnotrachelus*, western tubenose goby *Proterorhinus semilunaris* and the Chinese sleeper *Perccottus glenii*). More than 30 different parasites have been detected. The most widespread and/or numerous were: the ciliate *Trichodina domerguei*, metacercariae of digeneans; eyeflukes of the genus *Diplostomum* and *Tylodelphys*, encysted larvae of *Holostephanus luehei*, *H. cobitidis*, *Apatemon gracilis* and *Echinochasmus* spp. Periodically, glochidia of unionids (*Pseudoanodonta complanata*, *Unio pictorum* and *U. tumidus*) have appeared in great numbers. With the Chinese sleeper, the tapeworm *Nippotaenia mogurndae* (Mierzejewska et al. 2010) and monogenean *Gyrodactylus perccotti* (Ondračková *et al*. 2012) were introduced to Polish freshwaters, like the *Gyrodactylus proterorhini* was with the gobies fish (Mierzejewska *et al*. 2011). Larvae of nematodes of the genus *Eustrongilides* spp. have appeared in all studied species, aliens and natives as well. Living specimens encapsulated on mesentery or free in the body cavity were detected in 10 to 50% of fish, depending on the species or sample time. However, changes associated with eustrongylid infection have been noted in 100% of the Chinese sleeper and in many representatives of the other fish examined. Considering pathogenicity of the parasite, strong populations of final and intermediate hosts in the ecosystem of the Włocławek Reservoir, the parasite could play a key role in the expansion process of host-species at least in this area. Typical for the studied fish was the qualitative homogeneity of parasite component communities, differentiation between them depended on presence of a small number of specialists and quantitative distribution of generalists.

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On the invasive character of a population of *Phoxinus bigerri* Kottelat, 2007 in a small river of the Atlantic watershed of Galicia (NW Spain)

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During the summer 2011 an electrofishing survey was carried out in 30 sampling stations of 21 siliceous rivers of Galicia (NW Spain). As a result of those sampling surveys, we have confirmed the presence of the Pyrenean minnow *Phoxinus bigerri* Kottelat, 2007 in the A Chanca River (Pontevedra, NW Spain). This communication is focused on the study of the demographic and biometric parameters obtained from the 704 specimens captured in this population. To be analysed by size class, and following Oscoz *et al*. (2006), the specimens were arbitrarily assigned to three size classes: <5 cm, 5-6 cm, and >6 cm. The presence of young-of the-year in the sample and the finding of six brightly coloured males showing clear spawning characteristics provide evidence that this fish species can be considered as naturalized in this river. Moreover, ours findings showed that both density and biomass were high (16.27 fishes/m^2 and 34.01 g/m^2, respectively), demonstrating the invasive potential of this fish species. By size class, the size class <5 cm showed the higher density with a value of 5.99 fishes/m^2, opposite in terms of biomass, the size class >6 cm showed the higher biomass with a 54.66% of the total (18.59 g/m^2). On the other hand, the mean condition factor was 1.29, being significant differences among size classes (Kruskal-Wallis test, p < 0.001). Thus, the lowest condition factor was found in the size class <5 cm with a value of 1.24, however not differences were found between 5-6 cm and >6 cm size classes, both with a mean value of 1.33 (Mann–Whitney U test, p = 0.908). Finally, available data on its present distribution in Spain show that *P. bigerri* has been translocated to the Duero River and some Northern basins, probably as a consequence of its use as live bait or even to provide forage fish for brown trout (Doadrio 2001, Elvira & Almodóvar 2001). At present, in Galicia this fish species had been only cited in the Navia River, draining to the Cantabrian Sea in the Bay of Biscay (Hervella and Caballero 1999), thus to the best of our knowledge this is the first record of *P. bigerri* in a Atlantic coast rivers of the Iberian Peninsula.

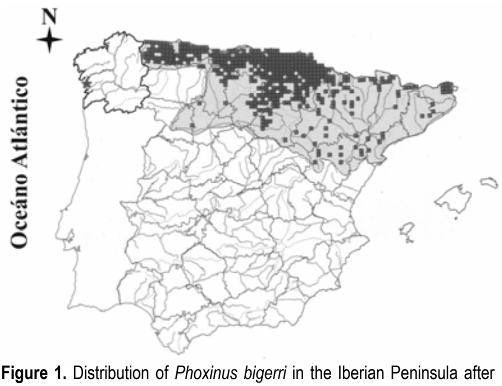

Figure 1. Distribution of *Phoxinus bigerri* in the Iberian Peninsula after Doadrio (2001) (Reproduced with permission of the author). The red star indicates new location described in this study.

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How do invasive bighead goby *Neogobius kessleri* compete with round goby *N. melanostomus* (Teleostei, Gobiidae)?

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Bighead goby (*Neogobius kessleri*) has been expanding from the Ponto-Caspian region into new non-native areas over the last decades successfully, as it has spread into many European rivers. In this study, diet spectrum, seasonal variation, ontogenetic changes, gut fullness, electivity and feeding strategy of individuals of bighead goby were analysed and the diet overlap between bighead goby and round goby was assessed. Also the possible impact of this invasive predator on native fish communities from the middle Danube was evaluated. Materials were collected from the Čunovo Reservoir and the Karloveské side-arm by fishing rods and/or electrofishing during 2008-2010. The diet spectrum of bighead goby was diverse: a total of 48 food types were observed. *Dikerogammarus* sp., Chironomid larvae and *Corophium* sp. were the most predominant food types. The diet composition varied over the seasons. In the Slovak part of the Danube, bighead goby has adapted to local food resources, and it prefers to be a specialist, where possible, but is flexible enough to use mixed strategy, when necessary. This enhances its capability to spread successfully. It appears that even if bighead goby and round goby exploit similar food resources, they differ in their proportional content. Differences in diet niche between these gobies were also found in their feeding behaviour and strategy, since round goby demonstrates higher flexibility towards general strategy. Both bighead and round goby have been assessed as species that may have a serious negative impact on the native fish species, especially those with similar food and habitat preferences.
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Invasive species facilitate spread and establishment of other alien species - case of great cormorants

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Invasive organisms are known not only to compete with native species, but to facilitate spread and establishement of other aliens, causing invasional "meltdowns" (Simberloff and Von Holle 1999). Such phenomenon was observed while studying forest habitat alteration caused by colony of great cormorants (*Phalacrocorax carbo sinensis*) in Curonian Spit (western Lithuania). The colony was first established in 1989, in 2011 its population has reached 3307 nesting pairs in ca. 12 ha of forested land. Highest density of nests (over 8 nests/100 m²) is in S–SW part of the area. Upper part of the colony originally was ca. 100 year-old pine forest of *Empetro nigri–Pinetum* association on nutrient-poor sandy soil, lower part originally was a mixed mesic forest stand.

Colonies of piscivorous birds introduce large amounts of biomass and chemical substances from aquatic to terrestrial ecosystems causing extremely high concentration of nutrients in soils, simultaneously transforming plant communities. In the studied colony, spatial and species structure of the forest community has changed: input of nutrients facilitated death or decline of tree layer, establishment of shrub layer, and the increase in numbers and area of mesotrophic and eutrophic non-forest plant species, among them 8 alien plants. The most common and abundant shrubs were alien eutrophic *Sambucus nigra* and *S. racemosa*. Invasive plants (*Acer pseudoplatanus, Impatiens parviflora, S. nigra*) were observed in the nesting area and in the surroundings of the colony, impacted by the flying birds. Maximum coverage of these plants were observed in the most active and most recent parts of the colony, apparently acting as pioneers in the area where forest plants had died away under impact of hypertrophication.

With increasing numbers of alien plant hosts, their pathogens have spread. *Erysiphe vanbruntiana* var. *vanbruntiana*, an obligate pathogen of *Sambucus* damaged to 60–100 % of foliage in the colony. A weak alien pathogen *Auricularia auricula-judae,* rare elsewhere in Lithuania, was abundant on dead branches of *Sambucus* spp. Two alien pathogens, infecting native plants were recorded in the colony as well: *Erysiphe alphitoides*, common on native *Quercus robur* damaged to 100 % of host foliage and recent arrival *Melampsoridium hiratsukanum* damaged to 20% of *Alnus* spp. foliage in the colony.

Thus, by transforming the forest habitat, eliminating competition from the forest species and weakening plants by excessive input of nutrients, great cormorants opened it to alien and invasive plant and fungus species. As a result, the colony area has become a focus for diaspores of alien and invasive species.

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Non-native species in Spanish transitional waters: a review of their origin, introduction pathways and main impacts

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Invasive alien species represent nowadays one of the major environmental issues in ecosystem conservation. Alien species alter ecosystems structure and function and can eventually lead to the extinction of native species. They also cause important economic and human health impacts.
Estuaries are among the most exposed ecosystems to non-native species introductions and establishment. Their physicochemical characteristics (a gradient from salt to fresh waters, with a high hydrodynamic component) along with the intense human activities -such as aquaculture or shipping- make them specially prone to alien species colonization. Furthermore, human activities often cause physicochemical and biological alterations to which exotic species can be better adapted than native species. In addition, in adjacent coastal environments the human induced spread is less intense and the high wave action often hampers species to settle. In European estuaries, around 20% of species are non-native.
To better understand how to manage and control non-native species in transitional waters in Spain, it is extremely important to know: which species had been introduced, which are better established and/or spreading, which are their origins and introduction pathways, as well as their impacts. Only in this manner the most efficient methods to i) prevent new introductions and/or spread, and ii) reduce their impacts, can be proposed and implemented.
In this study, the presence of aquatic exotic species in Spanish transitional waters (*sensu* the European Water Framework Directive) was reviewed, along with their native range of distribution (origin), introduction pathways and major environmental, economic and health impacts. An exhaustive review of ca. 400 references (scientific papers, books, reports, internet database searches, and unpublished records from experts) was performed.
25 autotroph species - 16 algae, 1 dinophyte and 8 vascular plants – and 59 animal species - 22 fish and 37 invertebrate species- were catalogued. They were mainly native to America and Asia. Most of autotrophs (plants and algae) have been introduced from aquaria, aquaculture and/or biofouling, whereas the majority of animal species arrived to transitional waters through biofouling, ballast waters, fishing and/or aquaculture.
Among the principal impacts, exotic species usually alter the habitat and/or out-compete native species for food and space. They can also reduce native biodiversity by predation (e.g. *Acipenser baerii*), by declining of resources through competition or through parasitic relationships (e.g. the invasive *Pseudorasbora parva* hosts *Sphaerothecum destruens,* a parasite causing native cyprinid death). Furthermore they often cause economic impacts: they can affect shipping (e.g. *Eichhornia crassipes* or *Sargassum muticum*), aquaculture (e.g. *Balanus trigonus*), agriculture (as *Pomacea* spp. or *Ludwigia grandiflora*) or hydrodynamic infrastructures (e.g. *Dreissena polymorpha or Mytilopsis leucophaeata*). Some of them also cause diseases or pose human health risks (e.g.. mollusc poisoning by *Gymnodinium catenatum*).

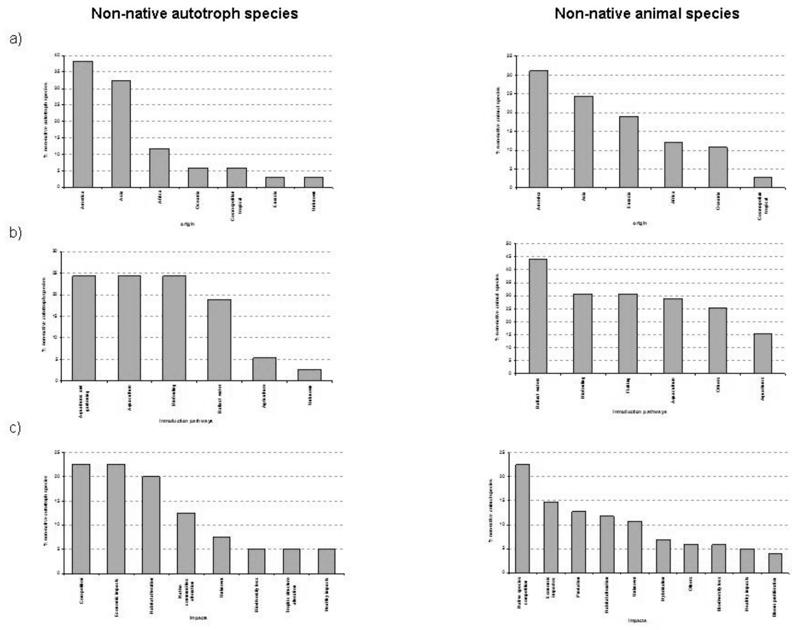

Figure 1. a) Origin, b) Introduction pathways, c) Impacts

Syntopy between two non-native terrapin species and native terrapins populations in the Ebro river (Castejón de Ebro, Navarra)

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During two years of a research project in Castejón (Navarra - Spain), four terrapin species were found in a small study area across three kilometres in the Ebro river. Datasets were obtained using visual linear transects and creels. The results reflect the coexistence of two species of non-native terrapins with two species of native terrapins. The relationship and interactions between the animals were studied. Each terrapin species was occupying a different place in the river and allow us to determine differences about their ecology and behaviour. It could help us to draw up a plan about how to fight against non-native terrapins in Spain.

Back on stage – Resumed evaluation of the leaf-spot pathogen *Mycosphaerella polygoni-cuspidati* as a second biocontrol agent for Japanese knotweed

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Since its introduction in the 19th century, Japanese knotweed (*Fallopia japonica*) has become a serious invader throughout Europe, as well as in many parts of the US and Canada. Consequently, the plant is listed as one of the world's top 100 invasive species. While being a pioneering colonizer of disturbed volcanic habitats and riparian ecosystems as part of its native Japanese flora, in its exotic ranges Japanese knotweed is characterized by vigorous growth and rapid rhizomatous spread. The troublesome invader impacts severely on native biodiversity and causes damage to local infrastructure with an estimated annual cost to the British economy of £166 million (Gerber *et al*. 2008, Williams *et al*. 2010). Conventional mechanical and chemical methods of control are both expensive and labour intensive, often requiring repeated applications in order to be effective, thus rendering Japanese knotweed an ideal candidate for classical biological control.

In 2003 a biocontrol programme commenced in the UK with the aim to research the potential and safety of natural enemies, associated with *Fallopia japonica* in its native range, for introduction as classical biocontrol agents into Britain. Field surveys and initial host- range studies under quarantine at CABI E-UK identified the psyllid, *Aphalara itadori,* and the leaf-spot pathogen, *Mycosphaerella polygoni-cuspidati* as the two most promising candidates based on damage inflicted upon the target weed and apparent host specificity. During a subsequent five-year project phase both agents were researched simultaneously until in 2008 a decision was taken to prioritise the psyllid thus putting the pathogen on the "back-burner". This ultimately led to the approval for release of the psyllid into the UK in 2010 (Shaw *et al*. 2011).

At the beginning of 2012 new funding has been provided by the UK government Department of Environment, Food and Rural Affairs (DEFRA) to resume work with the leaf-spot pathogen in order to complete the assessment of it biocontrol potential. Studies conducted during the first project phase (up to 2008) comprised the taxonomic identification of the pathogen (Kurose *et al*. 2009), evaluation of its infection biology and its field incidence in Japan, as well as host-range testing of the majority of non-target species according to an approved test-plant list (Djeddour *et al*. 2008). Research gaps to be addressed during the current second phase include details of the pathogen's life cycle and disease development, both in the field and under quarantine conditions, as well as completion of the host-specificity assessment using all non-target species not yet evaluated.

This poster will give a brief summary of the research undertaken during the first project phase and give an update on the current studies into the potential of *Mycosphaerella polygoni-cuspidati* as an additional biological control agent for Japanese knotweed.

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A ring test for ragweed seed viability using tetrazolium testing

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The North American annual ragweed (Ambrosia artemisiifolia, Asteraceae) has invaded several countries in East, Central and Western Europe. It threatens human health due to its highly allergenic pollen, agriculture as it occurs as a weed in several crops, and possibly biological diversity. In order to study methods to prevent further spread and to control or eradicate the plant, the European Commission is funding the project “HALT AMBROSIA” executed by a multi-national consortium.
One topic is defining ways to measure the success of various control measures. Since the seeds of the species are reported to stay viable for long time in the soil, the only reliable measure for control success would be to survey and reduce the number of viable seeds in the soil seed bank. Another important aspect is to prevent the enrichment of soil seed bank with new viable ragweed seeds. In order to study the variation of seed viabilities in different seed samples and to understand the comparability of results from different labs, we conducted a ring test. Five partners used 5 seed samples from different sources and assessed their viability using TTC tests. Variation existed between labs and between seed lots. The “best” seed samples (with the highest viability) were equally identified by participating labs.

The fate of ragweed seed in heat

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The North American annual ragweed (Ambrosia artemisiifolia, Asteraceae) has invaded several countries in East, Central and Western Europe. It threatens human health due to its highly allergenic pollen, agriculture as it occurs as a weed in several crops, and possibly biological diversity. In order to study methods to prevent further spread and to control or eradicate the plant, the European Commission is funding the project “HALT AMBROSIA”. One topic is the ability of the seeds of the species to survive adverse conditions in order to propose safe ways to dispose of seed-bearing plant material resulting from mechanical control measure, as e.g., mowing, in composting or biogas plants. As a preparation for testing we ran a series of lab experiments to find the temperature limits for seed viability. Seeds were exposed to different temperatures in different moistures and for different periods of time. Viability was assessed using TTC tests. Dry seeds were able to survive 60°C for 72 hours, whereas wet seeds were killed even below 50°C.

The contribution of post-harvest ripened ragweed seeds after cut for control

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The invasive annual plant *Ambrosia artemisiifolia* L. (Common ragweed) started to spread in Austria massively around 1980. Besides agricultural fields, road shoulders turned out to be favourable habitats for establishment and further spread. Machines used for mowing the shoulders and batters along any roads contribute most to the spread of ragweed. Common practice of control in such habitats includes leaving the biomass. We studied the post ripening potential of flowers/young seeds from branches cut at different developmental stages. All cut branches were left at the ground for post-harvest ripening until end of autumn. The seeds gained from the experiments were tested regarding their germination capacity and dormancy/viability (Tetrazolium-test). All treatments finally produced at least some ripened seeds. Flowers with soft ovaries developed only 5 seeds whereas all flowers with hard or near to hard ovaries produced many ripened seeds. Flowers with fresh stigmas developed at least a few ripened seeds. But the high number of ripened seeds in all other groups indicates the enormous capacity of post-harvest ripening of ragweed ovaries just after finishing flowering stage even if they are cut off from resource supply. Germination rates of the seeds depended on the different time available for finalizing the ripening process. The few ripened seeds developed from stage 1 (cut at Aug. 18th) and 2 (cut at Sept. 9th) branches germinated by 60 %. But this partition cannot be seriously interpreted because of low n=5. Stage 3 branches (cut at Sept. 14th) provided seeds which germinated by 27 %, stage 4 (cut at Oct. 1st) seeds already germinated at rates of 43 %, and seeds that were cut at Nov. 15th germinated at the rather high rate of 87 %. The latter differs significantly (p=0.0345, Tukey) from the germinability rates of seeds with less time left for post-harvest ripening. Remaining non-germinated seeds were not viable. The traditional cutting regime of road shoulders in Middle Europe includes 1 or 2 cuts before summer, hardly any cut during summer and 1 last cut in Sept. or Oct. Previous studies showed that such cutting regimes end up in lots of viable seeds distributed by the mowers. The current study makes evident that leaving cut plant biomass in September or October at the managed sites even promotes the fill-up of the soil seed bank and enables further spread of ragweed. Up to this study the aspect of post-harvest ripening of ragweed seeds after cutting was underestimated. The high number of viable seeds developed from plants cut mid of September makes evident the mistakes that were made in trying to control ragweed by cutting. Further spread of Common ragweed to countries of Northern Europe will be facilitated if the potential of producing ripened seeds earlier than given in the literature increases. From our results we expect the production of first viable seeds already in the second half of August (at least in the Pannonian region). Therefore, Karrer *et al*. (2011) recommend the removal and burning of any ragweed biomass after cutting as of August.

Enhancing the efficacy of Japanese Knotweed s.l. taxa control using synthetic herbicides and integrated management strategies in the UK

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Japanese Knotweed *s.l.* taxa are persistent, pervasive plant Invasive Alien Species throughout the More Economically Developed Nations (MEDCs) of the world: no less so in Wales (UK). The current study will trial 23 current, proven integrated management and control methods in seventy-two 225 m^2 (triplicate & control) field trial plots (randomised where possible) at two sites in South Wales and in a series of glasshouse trials in Swansea University. The principal aim of the project is to highlight effective (and ineffective) management and control methods, under highly controlled field and glasshouse conditions. We hope that this approach will help to promote effective management of knotweed under a range of potential site-specific circumstances. Drawing extensively from European and North American experiences with knotweed, this trial should serve as a reference tool for Academics, Land Managers and Local Government to exercise their responsibilities in an integrated, optimised fashion.

Wrack burial reduces germination and establishment of an invasive cordgrass

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The effects of plant debris (wrack) burial on seed germination and seedling establishment of *Spartina densiflora*, an invasive cordgrass, were studied under greenhouse conditions and compared with field observations. Five wrack burial depths were applied: control without wrack, and 1 cm (1235 ± 92 g DW wrack m^{-2}), 2 cm (3266 ± 13 g DW m^{-2}), 4 cm (4213 ± 277 g DW m^{-2}), and 8 cm (6138 ± 227 g DW m^{-2}). Sediment pH, electrical conductivity, redox potential and temperature were recorded during the experiment. Quiescence increased with wrack load up to ~20% at 8 cm deep. Germination decreased with wrack load from 96% to 14%, which seemed to be related with anoxic conditions under the debris since sediment redox potential was as low as –83 ± 7 mV at 8 cm. Germination percentage increased and quiescent and dormant percentages decreased at higher daily sediment temperatures and with higher daily temperatures fluctuations, conditions that were recorded without or under low loads of wrack, indicating that burial probably caused unsuitable temperature environment for germination. *S. densiflora* did not show primary dormancy, but its seeds entered in a non-deep physiological dormancy below 1 cm deep in plant debris. The establishment of *S. densiflora* seedlings was also greatly reduced by wrack burial since only 6 seedlings (11 ± 5 % of germinated seeds) emerged above plant debris from 1 cm and all seedlings died from deeper than 1 cm. *S. densiflora* seedling development was also reduced by wrack burial. Field observations showed that no *S. densiflora* seedling grew at wrack accumulation areas with debris depths between 2 and 14 cm.

The invasive cordgrass *Spartina densiflora* in ecological restorations of salt marshes in the Gulf of Cadiz

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According to the Society for Ecological Restoration International (SERI, 2004), ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Today, the practice of ecological restoration is receiving immense attention because it offers hope of recovery from much of the environmental damage inflicted by misuse or mismanagement of the earth's natural resources, especially by technologically advanced societies.
Coastal areas around the world are highly affected by degradation, so many efforts have been aimed at restoring coastal wetlands. Wetland creation and restoration are frequently used to replace ecological functions and values lost when natural wetlands are degraded or totally destroyed. In this context, plant and animal invasive species play a very important role since in many cases they have been the cause of salt marsh degradation and may become significant management problems in restoration projects.
Cordgrasses (genus *Spartina*) are one of the most popular biotools in soft engineering salt marsh restoration projects, with some *Spartina* species extensively used for coastal protection, phytoremediation, habitat creation or restoration, amongst other uses. Nevertheless, special care must be taken when selecting *Spartina* plants in natural ecosystems for transplantation. A properly planned restoration project attempts to fulfill clearly stated goals that reflect important attributes of the reference ecosystem. Then, monitoring of the results and, if necessary, gradual readjustment of the governing factors, together form an essential part of restoration projects. Environmental monitoring of restored or created coastal wetlands has increased in recent years. Vegetation monitoring is essential to assess the success of restoration since primary productivity is an important function and indicator of success for salt marsh creation and restoration projects. In addition, a comparison with degraded and preserved areas allows us to determine the maturity and evolution of the restored ecosystem.
Until now, most of the salt marsh restoration projects have used *S. alterniflora* and *S. anglica* as biotools. However, little is known about restoration of European salt marshes using Small Cordgrass (*Spartina maritima* (Curtis) Fernald), the only native cordgrass in many European estuaries. Recently (since January 2007) an extensive restoration project (8.37 ha), based on plantations of *S. maritima* and *Zostera noltii* Hornemann, was carried out in the Odiel Marshes in the joint estuary of Odiel and Tinto rivers (south-west Iberian Peninsula).
This presentation offers a general view of the roll of the invasive cordgrass *Spartina densiflora* Brongn. in the restoration projects in the Gulf of Cádiz (south-west Iberian Peninsula). *S. densiflora* has been eliminated in some restoration projects with a relative success however new seedlings appears during the first years after restoration while *S. maritima* prairies occupy free spaces. In other project, restored areas have been colonized by massively by *S. densiflora*. This difference in the outcome of restorations projects in the same area in relation to *S. densiflora* invasion depends on the particular characteristics of the projects, their developments, designs and maintenances.

Pennisetum setaceum: a new threat to Mediterranean arid ecosystems of the Iberian Peninsula

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Worldwide, fountain grass (*Pennisetum setaceum* (Forssk.) Chiov) represents a major threat to drylands because of its high phenotypic plasticity and water use efficiency. In the Iberian Peninsula, this species was introduced in the early 90's in highly urbanized areas of the Spanish Mediterranean coast due to gardening practices. Nowadays, the species has already spread throughout the provinces of Seville, Cadiz, Córdoba, Almería and particularly, in Málaga, Granada, Murcia, Alicante and Valencia. The species was first documented in the arid ecosystems of Almería province in 2004. We have established a science-management interface to effectively implement scientific control actions on species in these ecosystems. First, we evaluated the invasion level by identifying the current naturalized populations of fountain grass in drylands of Almería province, where the invasion process is still in the initial phase. Second, we developed a management plan that includes the eradication of both peripheral and core populations of protected areas, and a set of society-oriented actions. It was identified fifteen naturalized populations, some of them are invading protected ecosystems, four in the Cabo de Gata-Níjar Natural Park and one in the Tabernas Desert Natural Landscape. The eradication actions have been started in the reserves, where there are clear environmental governance schemes. However, the complexity of environments regulatory frameworks outside protected areas can hamper the invader control. All over the world, there are many examples of invasion by fountain grass in arid ecosystems as a result of gardening, and their invasiveness was high enough tested. Nevertheless, in the Mediterranean drylands, where the species can have dramatic effects on arid European priority habitats, the invasion process is once again happening now. In conclusion, this study highlights the need for the real consideration of the scientific evidences on environmental policies for development of effective regulatory tools and techniques that involve the whole society.

Control of Vegetal Invasive Species in Islands transforming it in Paper and Cardboard to manufacture Packaging

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Exotic invasive species are, at this moment, the second menace and cause of loss of biodiversity and species extinction, only preceded by loss of habitat. In the Canary Islands there are many invasive plants, but *Pennisetum setaceun* subsp. *orientale* is expanding really quickly, it reduces the available space for native species and competes with them.

This proposal is based on the idea that, given the ineffectiveness of efforts to eradicate this plant, we could take advantage of it and use it as a raw material to make paper and cardboard. At the same time, it could help to generate a new local sustainable packaging industry and new jobs.

Almost everything consumed in the Canary Islands arrives by boat and is distributed on the smaller islands by airplane. The packaging covering these products is dumped in landfills on the islands. Even for exported agricultural products and souvenirs, we import the packaging from outside, generating more waste, so it would be a great advantage, to have local resources to create packaging with the possibility to reduce their ecological footprints. The hypothesis of applying this new material (paper or cardboard made of *Pennisetum* or other invasive plants), not only could help to eradicate them, they also could be removed from the Islands using exportable transport and the tourist flow.

We believe, according to External promoters and Institutions that support this Project, that if we offer to the society the possibility of use and obtain profit of invasive species, we will contribute to stop its expansion, and will make a long-term contribution to its control.

The paper industry has a reputation for its high environmental impact. The proposal does not pretend to create a large-scale industry, because local demand would not justify it. Our intention is to create the first of future highly sustainable small-local paper and cardboard industries. We propose an interdisciplinary project between designers, biologists, chemists and engineers, who will make sure that these units work with renewable energy, minimal use of water and will control the waste, ensuring that they do not cause adverse effects on the environment.

There are some companies who are interested on manufacturing certain products, but also depending on demand, we pretend to install small-local industry in rural zones. Along with process design for obtaining paper and cardboard, different packaging types will be adapted to the demands of the market.

Pennisetun setaceum subsp. *orientale* is also a big problem for other islands as Hawaii or Macaronesia, so we believe that our research results can be exported and adapted to companies and authorities around the World.

Management of exotic invasive plants in the Nature 2000 site of the Banyoles lake

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Lake Banyoles is the second largest lake in the Iberian Peninsula. The lake is part of a karstic system. Over the past decades, an ecological improvement of this natural space has occurred, thanks to a high degree of legal protection and a management geared towards the preservation of natural heritage. However, nowadays the main challenge for the management of the lake and its surroundings is to be found in the invasive exotic species. In the case of plants, the main problem with exotics species is focused in the riparian habitats. In this kind of habitats, exotic plants species such as *Pyracantha crenato-serrata*, *P. angustifolia*, *Ligustrum lucidum*, *Prunus cerasifera, Arundo donax* and *Lonicera japonica*, tend to become widely dominant in the areas where they penetrate. Other exotic plant species present in surrounds of Lake Banyoles are *Morus alba*, *M. nigra*, *Acer negundo*, *Ligustrum japonicum*, *Ligustrum ovalifolium*, *Robinia pseudoacacia*, and *Budleia daviddii*.

From 2004 to 2007 a first LIFE project was executed in Banyoles. With the main objective focused on the recovery of wetlands around the lake, this project included several actuations of elimination of exotic plants too. The strategy was the combined use of mechanical actions (cutting and clearing), with the use of herbicides (Glifosate 36%). In each treatment parcel, these two complementary methods were used along several years reiteratively, till achieve a significant reduction of the presence of exotic plants or even their complete extirpation. After that, in some cases native trees of river banks were finally planted, such as *Fraxinus angustifolia* or *Salix alba*.

At this moment, a new LIFE project is executed in Banyoles (2010-21013). Under the title "Improvement of the Natura 2000 habitats and species found in Banyoles: a demonstration project", "Projecte Estany" (LIFE+ 08/NAT/E/000072) its main objective is to design and implement a large scale intervention to combat, slow down and revert the decline in species and habitats of Community interest in the Natura 2000 Network space "Lake Banyoles", through the control of invasive exotic species, and the population strengthening of seriously threatened native species. One of the main lines of action is the control of invasive water fauna by population culling campaigns carried out against exotic fishes and turtles. But new actions to control exotic plants in riparian habitats are also planned following the efforts previously initiated in the area.

Unanticipated spatial benefits of biocontrol of an invasive thistle

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Biological control of invasive species focuses on the use of natural enemies that target particular pest species, typically with the goal of reducing local pest abundance or density. However, this objective ignores spatial aspects mediated by enemy effects on pest dispersal and spread. We show that, in addition to reducing seed production by the invasive thistle *Carduus nutans*, the biocontrol agent *Rhinocyllus conicus* also inhibits both release and dispersal of seeds by wind. This combination of effects generates large, though different, impacts on both spatial and local control in US and New Zealand populations. These unanticipated spatial effects of biocontrol offer significant potential management benefits. By reducing spread, biocontrol agents may reduce both treatment and search costs, resulting in more cost-effective biological control efforts. Furthermore, future screenings of potential biocontrol agents should include examination of their effects on pest dispersal and spread, in addition to their effects on pest abundance.

Life+ Project Estuaries of the Basque Country: control and elimination of *Baccharis halimifolia* L. in Urdaibai

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Baccharis halimifolia is considered one of the most dangerous invasive species of Spain (GEIB 2006). In the Basque Country its distribution area covers all the estuaries, from Txingudi (Irun) to Barbadun (Muskiz) (Herrera & Campos 2010). The most affected estuary is the Biosphere Reserve of Urdaibai (Bizkaia), where more than 300 hectareas are covered (A. Prieto, 2005).
The main objective of the Life+ Project "Restoration of habitats of the Basque Country's estuaries for community interest" is the elimination of the invading species *Baccharis halimifolia* in three estuaries of the Basque coast to assist the regeneration of the natural plant species. During the 2011, elimination works were carried out in over 190 hectares in the Biosphere Reserve of Urdaibai.
The elimination works are based on two control methods. The young specimens (lower than 50-75 cm.) are pulled out manually. The adult specimens are cut one by one, and brushed with an herbicide diluted in oil directly on the stump. Additionally, some test plots have been established in two different environments of the marshes, to compare the effectiveness of using water or oil as diluents in different concentrations.
Finally, a monitoring is implemented to check the results of the actions by establishing plots and transects Two months after the conclusion of the works, data of the recovery of the native flora, resprout of the treated specimens and seed germination are taken. The preliminary results show that the selected methodologies are effective, but it is necessary to continue with the control works to avoid the resprout. The native species are recovering satisfactorily, mainly species as *Phragmites australis*, *Atriplex prostrata* and *Juncus maritimus*. *Baccharis halimifolia* is present in all the plots, but its presence is decreasing. The average of resprout is over 38%, but variable between plots and transects (Figure 1).

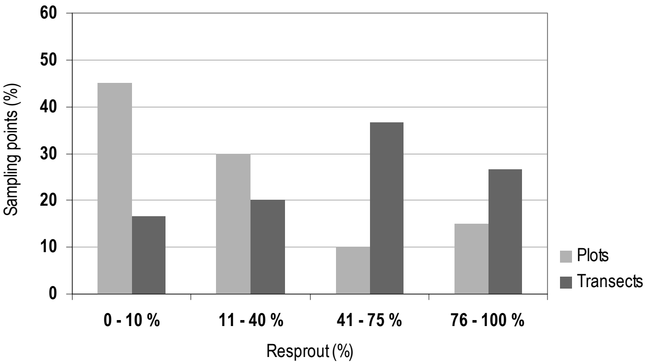

Figure 1. Resprout average per sampling point

Generally, greater the number of stumps, the effectiveness is higher (Figure 2).

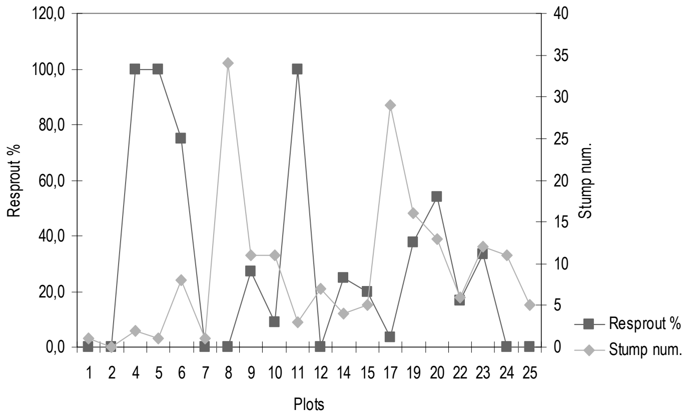

Figure 2. Number of stumps and resprout average per plot.

The most positive result is that the seed bank is decreasing because of the continued elimination works carried out for the last years (Gobierno Vasco 2011)

In regard to the test plots, it seems that the diluents and concentrations are not decisive for the effectiveness, but the specific conditions of the environment were this methodology is carried out (Table 1). In particular, in places with a high saltiness and flooding grade (Zone B), the results are much more effective than in dry lands (Zone A).

Table 1. Summary of results in test plots

	Zone A plots			Zone B plots		
	A1	A2	A3	B1	B2	B3
Stumps	22	11	17	23	24	20
Resprout	19	10	15	0	0	4
Resprout (%)	86,4	90,9	88,2	0	0	20,0
Seedlings	10	18	6	9	0	5

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Potential solutions for the control of riparian and aquatic invasive weeds in Europe: a review on the progress of classical biological control programmes in the UK

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The European Water Framework Directive requires as its most important objective "Good Ecological Status" to be achieved for all water bodies by 2015. The control of non-native species invading riparian and aquatic ecosystems and severely impacting on biodiversity as well as increasing potential flood risk and bank erosion thereby also falls under this EU legislation. Conventional mechanical and chemical control methods are both costly and labour intensive and often inadequate to manage invasive plant population on a catchment, national or cross-border scale. Furthermore, with Europe also striving to reduce overall pesticide use chemical herbicides registered for application in sensitive riparian and aquatic systems have and will become more restricted. Therefore we suggest that the most viable option to control non-native invasive plant species is classical biological control. This management strategy exploits the fact that most invasive plant species arrive in their new environments without the suite of natural enemies which contributes to the control of their populations in their native ranges. Classical biological control aims to redress this imbalance by reuniting those plant species with their co-evolved arthropods and pathogens which have shown to be highly host specific and suitable during extensive safety testing conducted under quarantine conditions following strict international protocols.

In order to fulfil its obligations under the Water Framework Directive, the UK is leading the research into this long-term and sustainable solution for invasive and riparian non-native plant species which are also common in many other European countries. Currently the UK government Department of Environment, Food and Rural Affairs (DEFRA) is funding research into the potential for classical biological control of four target weeds: *Crassula helmsii*, *Hydrocotyle ranuncoloides*, *Impatiens glandulifera* and *Fallopia japonica*. This paper will summarize the current status of each of these initiatives and discuss the biocontrol potential of agents currently under investigation.

Control of *Zantedeschia aethiopica* (L.) Spreng. (Arum lily) in Salvora Island. Maritime-Terrestrial National Park of the Atlantic Islands of Galicia

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After its introduction as ornamental species, the arum lily, *Zantedeschia ethiopica,* became an uncontrolled invasive weed in Salvora (Atlantic Islands, Galicia, Spain), where it found optimal conditions for its expansion, related to climate traits and animal agents for dispersal. In 2010, the first measure adopted was the manual extraction of rhizomes and bulbs, but this action turned out to be not so effective since there was an increase of populations and densities. A systematic Plan of Control and Monitoring was devised in 2012 involving GIS-mapping of invaded areas, selection of consecutive clearing of thickets as control methodology, schedule of clear-cutting (january, after blossoming and march before the blooming of other plants in spring), location of preferential areas, evolution monitoring and the performance of test spots for the application of possible alternative methods. Although total eradication seems to be impossible for the moment, the consecutive thicket clearing, at least twice yearly, resulted quite effective especially if repeated systematically.

Habitat restoration of small and shallow water bodies as a management measure for invasive American bullfrog *Lithobates catesbeianus*

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The control of invasive alien species is essential for securing native biodiversity. As for the American bullfrog, *Lithobates catesbeianus*, suspected to cause ecological damage to native amphibians around the globe, comprehensive management techniques are currently absent. We investigated two contrasting approaches to control the species in permanent, small and shallow water bodies in Flanders (northern Belgium). Small and isolated populations were actively managed through trapping with double fyke nets. The catchability of tadpoles averaged 6 % of the population with the specified sampling gear, implying feasible perspectives for a full eradication of the species when maintained over multiple years in the infested water bodies. In large and interconnected metapopulations, where active control is no option, we explored possibilities of passive management through habitat restoration. Using an experimental setup, we investigated the effect of complete drawdown with amphibian and fish removal versus predation by introduction of native northern pike, *Esox Lucius*, on bullfrogs. The presence of pike lead to a strong decline in tadpoles, while no effect of drawdown was present. Also, communities receiving pike harboured substantially less small and mostly planktivorous fish species (e.g. pumpkinseed, *Lepomis gibbosus*, and topmouth gudgeon, *Pseudorasbora parva*). Under these conditions of permanent, small and shallow water bodies, biomanipulation using a native predatory fish species can effectively lead to a change in food web interactions to the detriment of bullfrog. This method may thus be regarded as a candidate for effective and sustainable control of invasive bullfrog populations.

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Control of invasive American bullfrog *Lithobates catesbeianus* in small shallow water bodies

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Setting up cost-efficient control programs for alien invasive species requires the development of adequate removal methods in combination with insights in population size and population dynamics. American bullfrog, *Lithobates catesbeianus,* is suspected to cause substantial ecological damage around the globe through predation, competition and pathogen transmission (e.g. Sharifian-Fard *et al*. 2011). The species is listed in the top 100 of the world's worst alien invasives, for which drastic management measures are necessary. However, control of bullfrog populations is difficult due to the species' flexible life history and population biology. Moreover, no conclusive management measures have been determined. We investigated how double fyke nets could contribute to the management of bullfrogs by assessing the tadpole population size in 12 permanent, small (< 4000 m²), shallow water bodies. Population size estimate methods were applied, being (1) catch-depletion and (2) mark-recapture. Population density varied substantially among ponds, ranging from 950 to 120.804 tadpole individuals/ha. Catchability of bullfrog tadpoles proved to be consistent over ponds and methods, with one catch per unit of effort (one double fyke net for 24h) retaining on average 6 % of the population. Using these insights we projected the number of catch efforts needed to reduce tadpole numbers to a threshold that more than likely affects final population size. Predictions indicated that the use of eight double fyke nets is most cost-efficient. What the exact threshold number should be is debatable, but forecasts demonstrate only half of the budget would be needed when aiming at a drop till 100 than a decrease to 10 remaining tadpole individuals (Figure 1).

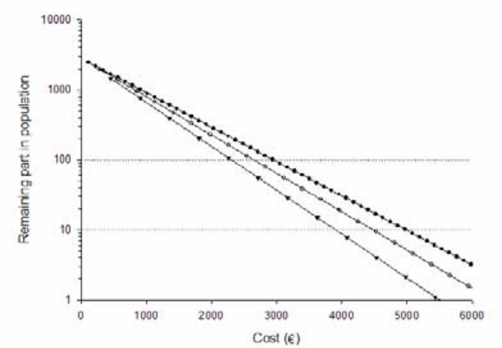

Figure 1. Relationship between the cumulative cost of each catch effort and the remaining population size of bullfrog tadpoles at the end of summer after depletion under various catch intensities. Catch intensities involve two (closed circles), five (open circles) and eight (triangles) double fyke nets per catch effort at a starting abundance of 5.000 tadpoles. The Y-axis is displayed on a logarithmic scale thus the relationship actually exhibits an exponential decay.

Given the fairly limited cost of the management with double fyke nets as compared to other methods, it may be worthwhile to fully reduce the tadpole population. The outcome of these experiments will be discussed in light of the feasibility of a full eradication programme for invasive bullfrog in the area.

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Pilot project to eradicate invasive alien smallmouth bass using a piscicide from a conservation priority river in South Africa: rationale, river treatment and way forward

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Invasive alien fishes are a serious ecological problem in South Africa, especially in its internationally unique Cape Floristic Region (CFR). This region has a very high percentage of endemic freshwater fishes (24 of 27 taxa), of which 18 taxa are endangered. The most severe threat is the impact of invasive alien fish species, especially the predatory smallmouth and spotted bass from North America. Eradicating invasive alien fishes from large river systems is no easy task, but eradications are possible in river areas above physical barriers using piscicides which have a proven track record of success, notably in the USA and Norway. To succeed, projects to eradicate alien fishes, which are very popular angling fishes in South Africa, should have as much support as possible from fellow environmental organisations, riparian land-owners and angling organisations. This project involved the first use of a piscicide in a river in the CFR to achieve a conservation objective. On 29 February 2012, the Rondegat River in the Cederberg mountains of the Western Cape Province of South Africa was treated with CFT Legumine at a concentration of 50ppb active rotenone for six hours.
The impact of the piscicide treatment on the river is being quantified through a research project funded by the Water Research Commission of South Africa under the leadership of the South African Institute of Aquatic Biodiversity. We await the outcome of this research before proceeding with further projects on other river areas in the CFR that have been identified as priorities for alien fish control.

Projecte Estany, a LIFE+ project for the recovery of native biodiversity through the demographic control of aquatic exotic species: aims and first results.

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Lake Banyoles is the second largest lake in the Iberian Peninsula. The lake is part of the a karstic system. Formerly, the population of fishes in Lake Banyoles was composed purely of five species: *Barbus meridionalis*, *Squalius laietanus*, *Gasterosteus aculeatus*, *Salaria fluviatilis*, *Anguilla anguilla*. Banyoles is one of the first places in the Iberian Peninsula where planned fish introductions. In 1910, were promoted the first releases of exotic fishes in the lake: *Cyprinus carpio*, *Scardinius erythropthalmus*, and others. Later, in mid XX century arrived *Esox lucius*, *Gambusia holbrooki*, and *Micropterus salmoides*. More recently other exotic fishes have been introduced illegally: *Perca fluviatilis*, *Sander lucioperca*, and others. At present the fish community in Lake Banyoles is in an extremely deteriorated situation. In 2010 more than 99 % of the lake's fish biomass corresponds to non native species.

Over the past decades, an ecological improvement of this natural space has occurred, thanks to a high degree of legal protection and a management geared towards the preservation of natural heritage. However, nowadays the main challenge for the management of the lake and its surroundings is to be found in the invasive exotic species, mainly the fish species. The proliferation of predatory exotic fish explains the disappearance or dramatic reduction of other water species, from herpetofauna to certain odonates. Indirectly, it explains too the critical state of conservation of native unionoids, a situation associated with the disappearance of native host fishes of their parasitical larval stages. Moreover, cascading effects have been observed in the ecosystem, such as a large increase of submerged plants.

Under the title "Improvement of the Natura 2000 habitats and species found in Banyoles: a demonstration project", "Projecte Estany" (LIFE+ 08/NAT/E/000072) is a four year project, from 2010 to 2013. The main objective is to design and implement a large scale intervention to combat, slow down and revert the decline in species and habitats of Community interest in the Natura 2000 Network space "Lake Banyoles", through the control of invasive exotic species and the population strengthening of seriously threatened native species. One of the main lines of action is the control of invasive water fauna by population culling campaigns carried out against exotic fishes and turtles. A combination of catching techniques is planned (nets, traps and electrical fishing), as well as the calibration of the effort required by means of a "feedback" process among the results progressively obtained and the design of the campaigns.

First results of this exotic control actions show a significant reduction of the adult fraction of *Micropterus salmoides* population. At the end of 2012, the reduction of 5+ and older individuals was superior to the 80%, respect the initial situation on mid 2010. On the other hand, several indicators used on the results monitoring show also a significant response. In this sense, density of several fauna species have increased. Is the case of the exotic crustacean *Procambarus clarkii* but also of the endangered native fish *Salaria fluviatilis*.

Eradications of mammals on islands: factors predicting success

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Introduced mammals on islands represent a severe threat to island ecosystems and to the survival of rare – often endemic – species of animals and plants. Biological control measures are often impractical or counterproductive to solve the issue, thus the complete extermination of the target species is the preferred method for ensuring the protection and survival of the native species. Currently there are some expert opinions and theories regarding which factors determine the success of eradications, but none have been widely tested, hence our interest in this topic. The aim of this research is to determine which factors enable a successful eradication. The factors that will be investigated will concern species-specific traits (i.e. body size, brood value, relative brain size, age of maturity), location characteristics (island area, geographical coordinates, climate) and others such as country wealth, year of eradication and techniques employed. We hypothesize that species with a large body mass, slow population growth rate and small relative brain size would be the easiest to eradicate. We further hypothesize that eradications are more successful on small islands and where the location presents a temperate climate. Species in temperate climates are more likely to face large annual variation in temperature and precipitation, whereas in tropical climates the conditions are relatively stable.

We base our analyses on the Database of Island Invasive Species Eradications (DIISE), which provides an extensive record of eradications conducted on islands across the world: it comprehends nearly 1500 eradication attempts of 35 mammal species, mainly goats, cats, rabbits and rats. Our results will indicate under which conditions eradications are most likely to succeed and thus they will highlight the most important parameters to be taken into account when planning an eradication campaign.

Tracking origins of the highly invasive horse-chestnut leafminer using herbaria and minibarcodes

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Determining the origin of alien invasive species is crucial to developing invasive species management strategies (Roques *et al*. 2011). However, the origin of many alien species remains uncertain because of the lack of historical data. For instance, the moth *Cameraria ohridella* (Gracillariidae) was described in 1986, as a genus new to Europe and had managed to invade almost all Europe since 1989. Its larvae are leaf miners on the white flowering horse-chestnut (*Aesculus hippocastanum*), causing significant damage to their summer foliage. The fact that the appearance of *C. ohridella* in much of Western Europe has been so recent and dramatic, without earlier detection by entomologists, has made its origin a subject of debate (Lees *et al* 2011a). Originally thought to be a relict species in the Balkans, a more recent hypothesis is that the moth is an example of a sudden host plant shift to horse-chestnut, probably from maple or sycamore (*Acer spp*.), maybe combined with long distance translocation. Examination of horse-chestnut samples in seven historic herbarium collections revealed that almost half of 71 sheets had leaf mines with larvae/pupae inside. This material came from natural populations in Albania and Greece and dated from 1981 back to 1879.

We extracted DNA from 54 archival larvae and used five COI minibarcode primer pairs developed specifically for *C. ohridella*. We successfully amplified DNA minibarcode fragments from 10 larvae extracted from herbarium specimens from 1936 to 1981. These archival sequences confirm an identity and Balkan origin for *C. ohridella* and the herbarium data set its history back by over a century. The herbaria reveal three previously unknown mitochondrial haplotypes. We also detected local outbreaks back to 1961 and dynamic frequency changes, which may be associated with road development (Lees *et al*. 2011). In particular, comparison with a temporal series of herbarium samples (1936, 1974 and 1981) with a modern sample from Karitsa in E. Greece suggests the frequency of the invasive haplotype A has been increasing rapidly even within the Balkans. This case history demonstrates that herbaria are greatly underutilised in studies of invasive species origins, herbivore biodiversity and insect-plant interactions.

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Air-borne spread of *Ceratocystis platani* by saw dust.

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Ceratocystis platani (J.M. Walter) Engelbr. & T.C. Harr. is the agent of the canker stain of plane trees, a lethal disease spreading in South Europe. Canker stain is probably indigenous to the forests of North America (Engelbrecht *et al*. 2004), where it is not dramatically dangerous because the native sycamore, is fairly resistant to it. The fungus was introduced into Europe during the second World War by infected wood. The pathogen spread in the host by entering an existing wound or through root anastomoses between neighbouring trees.

Pruning operations and damaging of the roots are the main causes that ensure the spread of the pathogen. During sanitary operations considerable amounts of infected sawdust may be produced and the parasite can survive for long periods (Panconesi, 1999; Grosclaude *et al*. 1996). Aim of this study was to ascertain the spread of fungus by sawdust during sanitation cuts.

24 'Airborne Inoculum Traps' (AITs) were prepared in laboratory by using Whatman filters: 11 AITs were placed along a street with infected trees, and the remaining 13 in the neighbouring streets. These traps were placed a week before the cutting of infected trees, and removed 4 hours after sanitation. AITs were washed and the solution was centrifuged to obtain a pellet for DNA extraction. A real time PCR assay was developed, by using TaqMan chemistry, designing specific primers and probes from two different genes: ITS (Internal Trascribed Spacer) and CP (cerato-platanin).

Both the markers were specific and able to detect *C. platani* DNA into the AITs.

Infected saw dust was always found within 100m from the felled trees and often within 200m. According to our results traps farer than 200m resulted always free from *C. platani* DNA.

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On the distribution's patterns of alien species at the Moscow region

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884 species of vascular plants was found in the alien flora of the Moscow region to the beginning of 2012 (Majorov *et al*. 2012, in press). It's 299 species more than in the previous study (Ignatov *et al*. 1990). In addition, the naturalization of 60 species were found only in botanical gardens. Thus, the number of alien species is almost equal to the native flora of the Moscow region.

The changes in the values of transport vectors was identified in the analysis of new records. In 1980-1990 years large number of new alien plant species was associated with the railways. At present the role of this vector is significantly lower. This result, first, associate with regular using of herbicides and mowing of railway embankments. Secondly, the import of grain to the Russian Federation considerably reduced.

There are new vectors of introduction. Currently, a large number of ornamental species were imported to the Moscow region, including plants from the countries of Central Europe. Together with woody plants in the coma of land *Claytonia perfoliata*, *Brunnera macrophylla* s. str. was introduced. *Trifolium dubium*, *Helipterum manglesii* were brought as an admixture to lawn grass seeds. The dispersions of *Thymus praecox*, *Viola sororia*, *Phlox subulata*, etc. taking place from the cultivation. In last years there are many naturalized tree species of Rosaceae: *Rubus alliganensis*, *Aronia mitschurinii*, *Prunus pensylvanica*. Probably, some alien species spreaded from cultivation in the botanical gardens, for example, *Geum macrophyllum*, *Flueggea suffruticosa*, *Adenocaulon adhaerescens*, etc. Some species were grown by amateur gardeners, for example, *Gilia capitata*, *Convolvulus tricolor*, *Coreopsis grandiflora*, untraditional for the Moscow region plants, cultivated only in recent years. *Sagittaria platyphylla*, *Pistia stratiotes*, *Cabomba caroliniana* got into reservoirs of the region from aquariums culture. The appearance of some species was unexpected and unpredictable, for example, *Ruscus hypophyllum*, *Rubus caucasicus*, *Lactuca biennis*. Thus, the change of the main vectors of introduction can be traced clearly. The proportion of naturalized plants from the cultivation became more, than some decades ago.

The environmental properties of some invasive species are changing. Thus, *Impatiens glandulifera* grows in wet dumps and the river valleys. In recent years this species active settles along the wet footpaths in spruce forests. The hybridization of invasive goldenrod S*olidago gigantea* with native *S. virgaurea* was noted, the previously unknown (6 points!).

Rapid changes confirm the relevance of monitoring alien flora. These changes reflect the socio-economic developments in Russia over the last 10–20 years.

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Migration routes of *Ambrosia artemisiifolia* throughout Austria and neigbouring countries indicated by DNA microsatellite analyses

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Common Ragweed (*Ambrosia artemisiifolia*, Asteraceae) is an important agricultural weed and a serious risk for human health due to its highly allergenic pollen. The plant was introduced in Europe from Northern America in the late 19th century. Until the early 1990ies *A. artemisiifolia* was a rather rare plant of disturbed anthropogenic habitats. In recent years its abundance strongly increased, also in Austria. The invasion of *A. artemisiifolia* started into Western and Eastern Europe, and probably consisted on the one hand of expansions of long-established populations and associated migration events and on the other hand of recent introductions from contaminated bird and crop seeds. Therefore, our aim was to genetically identify possible sources and migration routes of *A. artemisiifolia* in Austria.
Here, we present results of our DNA microsatellite analyses of *A. artemisiifolia* based on a comprehensive population sampling in Austria, i.e. overall 59 populations represented by 1066 individuals including 46 populations (i.e. 882 individual plants) from Austria were analysed using six DNA microsatellite regions. To uncover different sources and migration routes the sampling also comprised neighbouring countries, i.e. three population samples from Italy, one from Germany, three from Hungary, two from Russia and two from Slovenia, as well as two from bird seeds.
We found overall low to moderate levels of population differentiation indicating comparatively high levels of gene flow among populations. We observed no isolation-by-distance pattern as is typical for invasions still under progress. However, gene diversity was high reflecting again high levels of gene flow. Given this high dynamics, genetic structuring was shallow; however, a Bayesian Clustering Admixture Analysis identified three genetic groups within our *A. artemisiifolia* sampling: One of these groups clearly reflects the expected main invasion direction from east (Hungary) to west (Eastern Austria). This gene pool also includes the bird seed samples. However, beside this major route two additional gene pools were uncovered.

Relationship of geographic distribution of the most characteristical invasive plant species in habitats adjacent to the transport corridors within the territory of Daugavpils city

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With the development and expansion of human economic activity, a rapid spread of plant species outside their natural regions of origin is also taking place. With respect to the main dispersal agent, they may be divided into (a) terrestrial "transport habitats", including road verges and ditches as well as railway embankments and stati-ons; and (b) water "transport habitats", including river and stream bank (Pyšek and Prach 1994).

The altered disturbance regime in plant communities along corridor edges and vehicle traffic facilitate the spread and establishment of invasive non-native plant species (Hansen and Clevenger 2005).

Daugavpils is situated at the crossroads of significant auto and railways. An advantageous geographical location has made the city a significant industrial, educational, and cultural centre and a transport junction in Latvia, which is of importance for Lithuania and Belarus. In Daugavpils case, transport networks are among the most important terrestrial "transport habitats".

The distribution of invasive species along the transport corridors was mapped in grid cells of 500 × 500 m. The total number of grid cells was 348. Invasive species along the transport corridors were found in 290 quadrants (83.3 %). The species were classified, following Pyšek *et al*. (2004), as native, alien, casual alien, naturalized, invasive, transformers or weeds.

In the Daugavpils city area along the transport roads, 60 species of invasive plants were found: 11 species of trees, 21 species of shrubs, 28 species of caulescent plants. The most frequent species are listed (Table 1).

The found taxa are representing 20 families.

As a result of research in habitats adjacent to the transport corridors, 13 most common site-specific invasive plant species were studied. In habitats adjacent to the transport corridors as major infested habitats (% of the total number of quadrants infested by the plant in the city) the most typical are tree plants - *Acer negundo* (81.4), biennial and perennial caulescent plants - *Armoracia rusticana* Scherb. P.Gaertn. (78.4), *Bunias orientalis* L. (79.1%), annual caulescent plants - *Erigeron canadensis* L. However, only two taxa have been found in more than 50% quadrants (% of the total number of quadrants infested by the plant in the adjacent transport corridors) – *Erigeron canadensis* (87.2) and *Acer negundo* (63.4).

The highest concentrations of invasive plants have been observed in areas where there are intersections of motor roads and railways, as well as in areas, where roads are crossing or passing by territories of cemeteries or allotments.

Table 1. The most typical invasive taxa identified in habitats adjacent to the transport corridors within the territory of Daugavpils city

Scientific name	Number of grid cells in which the species is recorded in Daugavpils city	Number of grid cells in which the species is recorded in Daugavpils city (%)	Number of grid cells in which the species is recorded along the transport corridors	Number of grid cells in which the species is recorded along the transport corridors (%)	Transport corridors/Daugavpils city %	Area of origin	Dispersal	Main way of regeneration	Status
Acer negundo L.	226	64,9	184	63,4	81,4	N. America	water, wind	seeds	transformer
Armoracia rusticana Scherb. P.Gaertn.	148	42,5	116	40,0	78,4	Europe	man, water	roots	naturalized
Bunias orientalis L.	158	45,4	125	43,1	79,1	Eurasia	man, wind, water	seeds	naturalized
Phalacroloma septentrionale (Fern. et Wieg.)	108	31,0	56	19,3	51,9	N. America	wind, man	seeds	naturalized
Erigeron canadensis L.	276	79,3	253	87,2	91,7	N. America	wind, man	seeds	naturalized
Galinsoga parviflora Cav.	118	33,9	71	24,5	60,2	N. America	wind, man	seeds	naturalized
Helianthus tuberosus L.	133	38,2	86	29,7	64,7	N. America	man	toberous root	naturalized
Impatiens parviflora DC.	89	25,6	58	20,0	65,2	Asia	animals, man	seeds	naturalized
Lepidium densiflorum Schrad.	85	24,4	73	25,2	85,9	N. America	wind	seeds	naturalized
Malus domestica Borkh.	155	44,5	103	35,5	66,5	originated in cultivation	man, animals	seeds	naturalized
Sisymbrium loeselii L.	100	28,7	82	28,3	82,0	Asia	animals, man	seeds	naturalized
Solidago canadensis L.	151	43,4	94	32,4	62,3	N. America	wind, animals, man	seeds	naturalized
Syringa vulgaris L.	138	39,7	93	32,1	67,4	Europe	vegetative	roots	naturalized

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Passive dispersal by waterfowl of seeds of *Spartina densiflora* and *Ludwigia grandiflora*, invasive species in wetlands and Mediterranean saltmarshes

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Passive dispersal of seeds by waterfowl was studied for four plant species from wetlands and Mediterranean saltmarshes, the exotics *Spartina densiflora* and *Ludwigia grandiflora*, and the native *Arthrocnemum macrostachyum* and *Suaeda vera*. Ten mallards (*Anas platyrhynchos*) and 10 greylag geese (*Anser anser*), each ingested between 268 (*S. vera*) and 500 seeds (*L. grandiflora*), then recovery in faeces and retention time in the gut were recorded during 72 h.
The seeds with the highest recovery rates were those of *L. grandiflora*, with a mean of 1788 ± 22 and 1779 ± 30 in mallards and geese, respectively; and with a recovery rate of over 35 % in both cases. The seeds of native species (*A. macrostachyum* y *S. vera*) had similar recovery rates lower than *L. grandiflora*. For *A. macrostachyum*, 480 ± 20 seeds (9.70 % of ingested seeds) were recovered from mallards, and 366 ± 14 seeds (7.39 %) from geese. The mean number of *S. vera* seeds recovered were 260 ± 18 (9.70 %) in mallards, and 151 ± 5 (5.63 %) in geese. *S. densiflora* was the species with the lowest number of seeds recovered. After 72 h, only 70 ± 4 seeds were recovered from mallards and 31 ± 1 seeds in geese (recovery rate of 2.20 % and 0.79 %, respectively). This suggests that *S. densiflora* has a low capacity to disperse by geese and ducks, which digest them with relatively high efficiency. The seed coat for this invasive species is a fine membrane which is easy to remove. Of the 4 species studied, *L. grandiflora* is the one that has the hardest seed coat, and highest seed survival after gut passage.
Retention time in the gut of geese was variable. Some 90% of those seeds recovered were egested within 5 h for *A. macrostachyum*, within 10 h for *L. grandiflora*, and within 14 and 20 h for *S. densiflora* and *S. vera*, respectively. For all species, the model retention time was 3 h. In the case of mallards, 90 % of seeds were egested within 28 h for *L. grandiflora*, within 8 h for *S. vera*, within 6 h for *S. densiflora* and within 5 h for *A. macrostachyum*.
For both waterfowl species, although most seeds are egested within a few hours of ingestion, there is a long tail in the retention time with some seeds being retained for over 48 h. This suggests that long-distance dispersal is possible over hundreds of kilometres or even over 1000 km, since mallards and geese fly at a speed of around 75 km/h.
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Case studies on the alien flora of the vicinity of cemeteries in East Latvia

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In recent years various changes in surrounding environment regularly are being discussed. One of the changes is entrance of alien species into local plants society, habitats (McNeely 2001). Distribution of alien species in specific territories depends both on the taxon itself and characteristics of ecosystem. However in practice they can be evaluated only when invasion took place (Pyšek *et al*. 2004). Distribution of alien plants is increasing rapidly in Latvia. Looking at the territory of Latvia it has been observed that one of the centres of distribution of such species is cemeteries. Hitherto insufficient attention has been turned to environmental and ecological researches of cemeteries in Latvia. In the territory of Latvia formation, arrangement and maintenance sometimes differs, it is defined by diverse cultural and religious traditions. Influence the political process only in the second half of the 18th centnry Latvian began to plan the planting of trees in cemeteries, which received appearance of the park (Berkholz *et al*.1895). Visual appearance of modern Latvian cemeteries has formed over 300-400 years; the process of their formation was influenced by various factors. Visual condition of the cemeteries, even of the neglected ones, resembles society conceptions, taste, interests, cultural habits, actual tendencies in choice of plants and social aspects. Since various exotic and decorative alien species are used in greenery of cemeteries there is a risk that will proceed if they will leave their distribution uncontrolled, their “travel” outside of the territories of the burials. (Gudžinskas 2005). The municipalities are responsible for overall condition of the cemetery and its spruce depends on the allocated finances and management strategy in each separate municipality.

It must be noted that cemetery plants are much more resistant to various environmental factors, e.g. dryness, darkening or direct sunbeams on contrary, barren etc. Therefore these plants are wittingly used for greenery, however these biological characteristics make their naturalization easier. Naturalized decorative alien plant, which are grown for long time in Latvia, are also popular plant in cemeteries. The majority of alien plants get into vicintly of cemetery from graves, the most important place in cemeteries, where migration of plants is taking place, is waste collection place, where weeded and cut parts of plants and dried flowers are brought. Uncontrolled formation of weste places and irregular management of cemeteries facilitate entrance of alien plants into the territory of cemetery vicintly.

In the territory of Eastern Latvia the researches were commenced in 2010 studying the Daugavpils City cemeteries. Extended these studies started in the summer of 2011 and are ongoing now as well. At this moment in the northern part of Eastern have surveyed 32 cemeteries. Diversity of alien plant species was research around cemetery, where no places of burials are located, most commonly beyond any kind of fence / delimitation (wooden, stone, hedge etc.). The vicinity of cemetery was thoroughly inspected within radius of 50 meters in average from the fence by searching alien plant species in various habitats. 47 alien species were found, this number testifies that cemeteries are important centre of invasion of alien plants, the number of found alien species in territory of one cemetery vary from 7 to 27. 67 % herbal plants, 23 % shrub and 10% tree species were found. Most commonly were traced such species as *Vinca minor, Sedum sexangulare, Euphorbia cyparissias, Dianthus barbatus.* Primary results show that the greatest numbers of plants was found in Catholic and in Orthodox cemeteries which make up 65 % of all surveyed cemeteries, it is related to cultural religious traditions in these territories.

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How many Ant Species are Being Shipped Around the World?

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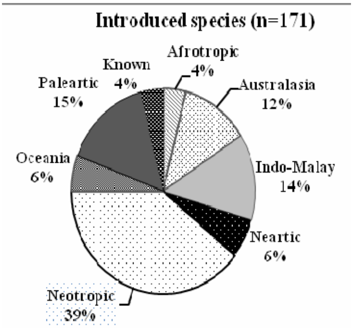
Global trade routes facilitate the dispersal and establishment of ant species in areas outside of their native biogeographic ranges. We used data on the arrival and establishment of exotic ants in USA (Suarez 2005), Netherlands (Boer and Vierbergen 2008) and New Zealand (Lester 2005) to estimate the proportion of species shipped worldwide, and compare these numbers to the known and estimated numbers of established species using Chao 2 richness estimator. We also examined the region of origin of both introduced and established species.
The number of exotic ants introduced and established to new regions is greater than we currently know. Of the approximately 12.500 described species of ants, over 147 have introduced populations outside of their native ranges (Suarez 2005). Our study, however, suggest that this value should be much higher (i.e. 810 species in temperate regions). Results suggest that only half of the introduced species (i.e. 420 species) will manage to establish viable populations in new regions. This value contrasts to some extent with data from New Zealand, where only a quarter of the intercepted species (17 of 66 ant species) have managed to establish viable populations (Lester 2005).
When examining the origin of ants introduced to new regions, the vast majority come from the Neotropic region (39%). Often established species come from the same biogeographic realm that they belong to or from the closest biogeographic realm. One first explanation is based on the “Climate matching” hypothesis (Williamson 1996). Species establish more successfully if introduced into a new region with similar physical and climatic conditions to their region of origin. Another second explanation is related to the humans and goods exchange between neighboring regions. Areas with a higher trade are more likely to receive a greater number of exotic species and to facilitate the establishment of exotic species by increasing propagule pressure (Lockwood 2005).
Acquiring a better knowledge on where goods that contain exotic ants come from and what are the ant species that arrives more frequently is important to target management actions efficiently and to prevent the entry and later establishment of exotic ants in new regions.

(a)



(b)

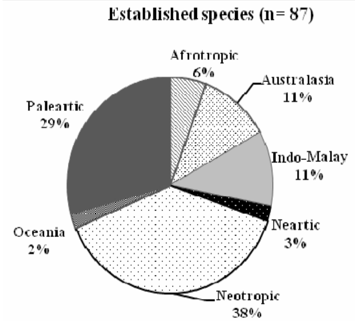


Figure 1. Pie charts showing the source biogeographic realms for introduced (a) and established (b) species that have arrived in New Zealand, the Netherlands and the USA respectively.

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A bridgehead effect in the invasion of the Western conifer seed bug in Europe?

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In Europe, almost 1600 alien arthropod species have already established and among them, some forest insects that represent a risk to European forests and plantations. The Western conifer seed bug, *Leptoglossus occidentalis* Heidmann (Heteroptera, Coreidea) is an insect native of Western North America, its original range extending from British Colombia to Mexico and from the Pacific Coast to Colorado. Since the 1950s the species spread eastwards and reached the East coast in the 1990s. In Europe, *L. occidentalis* was first observed in 1999 in Northern Italy. It expanded its range very quickly and within just a decade, the species colonized most of Europe from Norway to Sicily and from Portugal to Turkey. Even if this species is described as a good flyer little is actually known about its dispersal capacities. Isolated records in Germany, Spain and in the United Kingdom strongly suggested the occurrence of different introduction events, and its present distribution in Europe may have resulted from a combination of natural expansion with long-distance translocations through human activities (transport of eggs, nymphs or adults as hitchhikers). Using molecular tools we intended to precise the source of the European populations and the invasion routes. Here we present the preliminary results of a phylogeography study using mitochondrial gene sequence data (Cytochrome *b*) to compare the level of genetic variability in bug populations sampled across the entire native range in North America and in some European populations with regard to the date of first record in the country. Haplotype richness in Europe is limited compared that observed in the native range. Our first results suggest that the populations having invaded Eastern North America may have acted as a bridgehead for the European invasion which may not originate directly from the Western North American native range. Such a bridgehead effect has already been observed in some other invasive species such the Harlequin ladybird. New analyses using microsatellite markers are in progress which may allow us to obtain a better vision of the genetic structure in both native and invaded areas.

History and patterns of insect pest invasion of eucalyptus and citrus ecosystems in Portugal

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Citrus and eucalyptus are exotic perennial trees of economic importance in Portugal. Since their introduction in Europe, respectively in the 11th and in the 19th century, many species of insect pests invaded these ecosystems and became established. In this work, the history and patterns of invasion of eucalyptus and citrus ecosystems by alien insect pests in Portugal were analyzed and compared. Different traits were considered in the analysis, such as invasion history, pest status, feeding guilds, voltinism, host range, and geographical origin and dispersion.
In both systems, the number of invasions has increased exponentially during the last 50 years, leading to the emergence of new major pests. However, the pattern of invasibility of these two crop systems seems to differ. Over 60 insect pests, distributed among seven orders, namely Hemiptera, Coleoptera, Diptera, Hymenoptera, Lepidoptera, Orthoptera and Thysanoptera have been reported from citrus in Portugal. About two thirds are invasive species originating from different geographical regions; the other third comprises native species from Europe which shifted to citrus hosts. Regarding eucalyptus, ten invasive pests are known, including representatives of Acari, Hemiptera, Coleoptera and Hymenoptera, all of Australian origin, whereas three native species are known to occasionally cause damage to the root system on young eucalyptus plantations. Data on host specificity, damage and management control measures are also presented.

Tracing provenience and dispersal mode of gobies invading Switzerland by microsatellite analysis

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During the last decades, five bottom-dwelling fish species (*Ponticola. kessleri* – bighead goby / *Neogobius melanostomus* – round goby / *Neogobius fluviatilis* – monkey goby / *Babka gymnotrachelus* – racer goby / *Proterorhinus marmoratus* – tubenose goby) from the ponto-caspian region have conquered central European rivers and the Great Lakes. Wherever they establish, they proliferate to high densities, alter food webs and affect local fisheries. Dispersal corridors correlate with cargo vessel routes. In the case of the Great Lakes invasion, ballast water transport is indeed widely accepted as dispersal scenario. In the case of intra-european spread – for example to the Rhine - , natural dispersal mechanisms cannot be excluded. Although saltatory range expansions from harbour to harbour have been observed (personal communications), ship-mediated transport has not been proven.
Bighead gobies have recently been monitored in the Rhine at Basel. This is the first reported occurrence of a ponto-caspian goby species in Switzerland. Since most swiss waters drain into the Rhine, swiss aquatic ecosystems may be broadly affected by this immigration event. Expected ecological consequences include competition with *Cottus gobio* (European bullhead) and predation on the spawn of threatened or managed fish species such as *Chondrostoma nasus* (Common nase). On the socio-economic scale, ponto-caspian gobies will by extrapolation from experiences in Germany negatively impact pastime fisheries. We are currently establishing a microsatellite genotyping protocol for bighead goby based on published microsatellites[1-3]. We will then test for saltatory dispersal (indicative of ship mediated dispersal) versus continuous dispersal (indicative of natural dispersal). Additionally, we would like to correlate the genetic distance/similarity of harbour populations with vessel numbers recorded in public databases. This will allow us to estimate propagule pressure per vessel.The dispersal mode has implications for management perspectives. If non-native gobies rely on ships as vectors, their spread will be limited to upstream of Basel / Rheinfelden, since cargo vessels do not navigate upstream of the Rheinfelden dam. Rigorous regulatory measures could in this case limit small scale dispersal by private vessels and fishermen. However, if non-native gobies spread by natural dispersal, they are expected to establish in all climatically suited water bodies in Switzerland. Management would then need to focus on adapting present conservation schemes and wildlife management approaches.

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Social drivers of species introductions

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The introduction of species to new areas is a key ecological process with profound evolutionary consequences. It has been fuelled by human interventions at least since the emergence of epipalaeolithic cultures but it has been gaining momentum in recent times.
Much attention has been given to the introduction of dangerous organisms such as disease vectors or agricultural pests as well as the rapid expansion into new regions of selected species of insects and weeds. The progress of lowland species to higher elevation in mountain ranges, due to contemporary climate change, is also documented. Detailed inventories of species invasions in European countries and in Biological Reserves or protected areas have been carried out.
Existing evidence is reviewed under a different frame in the paper: the social attitudes and activities of Western civilization which sustain species invasions. In first instance which are the attitudes of urban inhabitants towards wild species and the trend to incorporate an even wider list of new species as pets. In the second place, the gardening services and the growing demand for new species both at home and in landscaping projects. In the third place the pressure of fishermen towards the introduction of new sport fish in continental waters. Hunters often introduce new game to preserves with a similar purpose.
The study of environmental impacts associated to urban and industrial activities, roads, dams and channel construction, mining, forestations, plus navigation and transport reveals how contemporary activities open biogeographical barriers to species. They also provide suitable habitats to their development and reproduction.
The combination of fresh attitudes towards wild species and a very intense disturbance on environments plus am expanding transport explain the growing species invasion.
Examples will be presented of invasions in forests, rivers and reservoirs, the Mediterranean Sea, and from genera or individual species of animals and plants which have turned up as powerful invaders.

Can waterfowl enhance the spread of invasive crayfish?

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In this study we propose to investigate if waterfowl-mediated passive dispersal by means of ectozoochory may play a significant role in the colonization of new territories by *Procambarus clarkii*, one of the most invasive crayfish species. A set of ecological experiments was performed using the mallard duck (*Anas platyrhynchos*) as vector model, and recently hatched crayfish (RHC) were used as propagules. We performed two types of experiments testing RHC attachment abilities. In the first one, we simulated swimming duck activity, dragging a dead duck under different conditions in water containing crayfish at a density of 400 ind./m^2. In the second experiment, we simulated a duck walking in swallow water, immersing mallard legs under different time periods into plastic containers with the same density of crayfishes as the one used before. A third experiment was performed to check if RHC can survive transport, adhered to the flying duck. Finally, desiccation resistance of RHC was analyzed under fixed temperature conditions (19ºC and 24ºC at a relative humidity of 35%). Our results show that crayfish attachment probability depends on time (X^2= 24.492; df=3; sig.=0.000) and water depth (X^2= 10.043; df=3; sig.=0.007). We obtained probabilities of crayfish adhering to a duck's paw of 0.7%, 2.7%, 5.3% and 12.7% for immersion periods of 1, 5, 10 and 20 seconds respectively. For the experiment in which we dragged a dead duck, we obtained attachment probabilities of 3.7%, 1.7% and 0.3% for water depths of 5, 10 and 20 cm. A probit analysis indicated that crayfish may survive and stay attached to a flying duck with a probability of 50% and 10 % for a distance of 2.3 Km and 6.3 km, respectively. Additionally, the same statistical test unveiled that crayfish are able to survive without water for 139 minutes with a survival probability of 50%, at both temperatures used. The LT_{90} was 195 minutes at 19ºC air temperature and 185 minutes at 24ºC. This work demonstrates that RHC ectozoochory is possible, and so waterfowl may enhance the spread of *P.clarkii* across river basins, therefore accelerating the speed of the invasion front.

Following aliens in Portuguese wind farms

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In the past few years, there has been increasing awareness about the invasive plants problematic in Portugal. This consciousness has motivated the implementation of several monitoring studies regarding alien plant species propagation in different Portuguese wind farms.

Bio3 is responsible for the monitoring of several wind farms in Portugal, were the presence of alien species has been reported as a problem. One example of these projects is the monitoring plan of Serra da Lousã wind farm, located at a Natura 2000 Site, where the presence of aliens *Acacia dealbata* and *Acacia melanoxylon* is well-known. The monitoring plan began in 2006, before the construction of the wind farm project, and we identified a large number of individuals of both species at that time, including adults and seedlings.

After the construction of the wind farm we monitored the area twice (2009 and 2011) and followed the evolution of alien plants cores. The data collected showed that invasive species are spreading along the wind farm structures, as roads and turbine platforms, and that there has been an increase in the number of individuals. New invasion sites were also found, suggesting that this increase is related to the construction of the wind farm.

In other Portuguese wind farm monitored by Bio3 the initial situation found was very different from the one found in Serra da Lousã. The presence of these species was scarce before the project construction: only few individuals of *Acacia delabata* were found outside the wind farm location and none was found in the exact location of the project. However, during the vegetation monitoring plan, two years after the construction, we identified four new invasion focus with *Acacia delabata* seedlings, located along the wind farm roads, where before there was no individual. The early identification of these new invasion cores will allow the immediate implementation of simple control methods, since there are no adult individuals yet. The quick action will improve the success rate of the control methods taken.

The data collected shows the importance of applying monitoring programs, who are simple to execute and little time-consuming, and control measures after the construction of wind farms is completed. The early identification of these new invasion locations will allow the immediate intervention and implementation of more effective control methods.

Quantifying the likelihood of invasion by global shipping

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The successful prevention of bioinvasion requires detailed knowledge how the global spread of species proceeds. Global shipping represents one of the most important vectors for the spread of invasive species but empirical data of ship movements has rarely been used to predict invasion dynamics. Combining global ship movement data with biogeography and environmental conditions, we quantify the likelihood of invasion through the exchange of ballast water of large cargo ships. The backbone of the study represents a database of global shipping containing nearly 1.400.000 ship movements of 30.000 large cargo vessels travelling between 1.300 ports during 2007. For each time a ship called a port, a likelihood of invasion is calculated depending on 1) ship movement-specific data such as travel time, ship type, and ship size, 2) environmental similarity of ports, and 3) biogeographical similarity of ports. Linking these invasion quantities with the network of global shipping, the model identifies high risk invasion routes, hot spots of invasion and major source regions from which invasive species are likely to occur. Model predictions agreed comparably well with observations from various locations in the world. The model allows us to investigate strategies to reduce the likelihood of invasion through global shipping.

Assessing pathways of introduction of marine aliens in European Seas: temporal and spatial patterns

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Identification and assessment of the pathways of introduction of alien species is essential for identifying management options to regulate invasions and prevent new introductions, and communicating related risks and costs to policy makers and high administration. By critically reviewing scientific/grey literature and online resources, 1360 alien marine species in European seas were identified, of which 1269 were linked to the most probable pathway(s)/vector(s) of primary introduction. Based on their reported year of introduction, trends in the numbers of introduced species per pathway/vector were assessed on a decadal basis and invasion patterns were described for each pathway. The overall trend of new introductions of alien species in Europe has been increasing (see Figure), with more than half (51.9%) of the species probably being introduced by shipping. The current rate of ship-mediated alien introductions in European Seas is one new species every ~three weeks. Marine and inland corridors (primarily because of the Suez Canal) were the second most common pathway of introduction (37.6% of species) followed by aquaculture (14.8%) and aquarium trade (3.9%). Species introduced by shipping or aquarium trade initially get established in one or more locations, usually in hotspot areas such as ports or metropolitan areas, and then they extend their range by natural dispersal and other vectors, without following a predicted common path. The most common invasion pattern of Lessepsian immigrants is to first get established in the southern Levantine basin, close to the Suez Canal, and then gradually spread to the rest of the eastern Mediterranean basin initially following an anticlockwise direction, and then northwards in the Aegean and westwards towards the Ionian Sea, further westwards along the Italian coastlines and western Mediterranean and also southwards to the North African countries. A frequent pattern of aquaculture-mediated invasions is that more than one sites of introduction (often temporally distinct) exists. These sites are colonized independently and self-sustaining populations are established, gradually expanding by natural processes. Aquaculture was the only pathway for which there was a marked decrease in new introductions during the last decade, presumably due to legally binding measures implemented at a national or European level. Many more species are expected to invade the Mediterranean Sea through the Suez Canal, as it has been continuously enlarged and the barriers for the invasion of Red Sea species have been substantially decreased. Similarly, increased transport through inland navigational European canals will assist more and more Ponto-Caspian species to extend their range into the Baltic and along the European Atlantic coasts. The increasing trends in worldwide shipping as well as within Europe will lead to an increasing trend in shipping-mediated new introductions. For many of these pathways, practical preventive measures are obtainable and there should be no delay in their application, e.g. the implementation of the Ballast Water Convention, more awareness raising among aquarium hobbyists and also implementation of a stricter legislative framework on the import of non-native aquarium species.

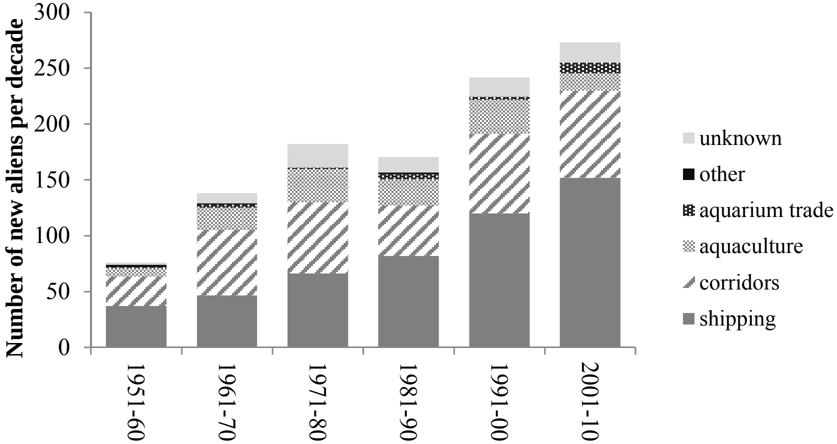

Figure 1. Temporal trends in the numbers of new recorded marine aliens in Europe per decade in relation to the pathways of introduction. Some species that were linked to more than one pathways were given a value of 1/k for each of the k associated pathways so that the overall contribution of each species to the total number of new aliens per decade was always 1.

Six degrees of preparation: analysing shipping networks as a pathway for invasive species

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Invasive species are able to spread significant distances beyond their natural dispersal ability with the assistance of anthropogenic vectors. In particular, the world wide shipping trade has been identified as a significant and increasing threat from invasive species as international trade continues to grow exponentially. Any ship is able to pick up an invasive species and carry it around the world before arriving at a country in which that species is not present. Often, the biosecurity agencies in the receiving country are only aware of the last port of call and have no knowledge of the previous ports visited, which could have been sources for invasive species. Clearly, this complex shipping network needs to be analysed in more detail to enable a better understanding of the potential for any arriving ship to carry an invasive species. I obtained a shipping network which shows, for every arriving ship to Australia, the previous ten ports of call. I used this network to estimate arrival likelihoods for 564 insect pests, not present in Australia. These arrival likelihoods were then combined with establishment likelihoods estimated from a SOM (Self Organizing Map) analysis to generate overall invasion likelihoods for all 564 species. This allowed me to identify those species with the greatest likelihood of invading Australia. Further, for any invasive species, Australian ports with high invasion likelihoods can be identified, and incoming ships can be ranked by invasion likelihood based on the Australian port the ship is arriving to and the last port of call before Australia. Finally, I tested the sensitivity of this model to test its resilience to variations in the model parameters. The work will show that this type of analysis can enable a more appropriate estimate of risk for incoming ships. I also outline an upcoming project, which will integrate this model into the Australian government's ship monitoring computer system, thereby enabling evaluation of incoming ships to Australian ports in real time.

Simulating Transport Conditions in Marine Invasive Species: Preliminary Results from a Global Replicated Stress Tolerance Experiment

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Successful marine invasive species possibly possess a higher physiological and/or genetical potential to establish in new environments than non-successful invasive species. During transport to new habitats, invaders might pass through a selective process during which they suffer from environmental stress. Conditions during human induced transport like long-term temperature increase on ship hulls or air exposure in land over transport in fishing gear might lead to selection for more stress tolerant individuals. The native marine invertebrates *Carcinus maenas* and *Mytilus galloprovencialis* in Portugal have already established stable invasive populations along the Pacific coast of North America. At the Marine Laboratory of Guia, University of Lisbon, we exposed individuals of *Carcinus maenas* and *Mytilus galloprovencialis* to air exposure and heat temperatures, respectively, to mimic stress conditions during voyages. Crabs and mussels were acclimatized in water baths to lab conditions for a one- week period. Experiments were designed in a two step procedure. During a first stress phase a subsample of 160 organisms suffered 80% mortality. Survivors recovered through an additional one week period and immediately stressed again during a second stress phase. Non pre-stressed organisms were exposed to the second stress phase as well. Mortality, byssus production for individuals of *M. galloprovencialis* and righting behaviour for individuals of *C. maenas* were observed daily during the second stress phase. The present study is part of a global investigation on the stress conditions marine invaders are subjected during transport, executed within the framework of the international training and research program GAME (Global Approach by Modular Experiments). Preliminary results will be presented. We hypothesize that within pre-stressed individuals mortality will be lower during the second stress compared to mortality within the non pre-stressed individuals. Finally, byssus production of pre-stressed mussels will be higher compared to non pre-stressed mussels and righting behaviour of pre-stressed crabs will be faster compared to non-pre-stressed crabs.

The potential role of an unregulated coastal anthropogenic activity in facilitating the spread of a non-indigenous biofoulant

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The magnitude of biological invasions is very much reliant on the rate of secondary dispersal following successful establishment of a non-indigenous population (Johnson *et al*. 2001). Whilst the clarification and quantification of all potential mechanisms of secondary dispersal thus remains a major goal for those aiming to mitigate or prevent future biological invasions, several coastal anthropogenically-mediated activities and their potential to facilitate the spread of non-indigenous species remain completely overlooked. The current study investigates the potential role of commercial periwinkle (*Littorina littorea* L. 1758) harvesting (see Figure 1) as an unregulated facilitator of both small- and large-scale geographic range expansion of an invasive oyster epibiont (*Ostrea chilensis* Philippi 1845), whose natural dispersal capacity is highly limited. The significance of this increasingly-dominating oyster epibiont (see Morgan and Richardson 2012) in relation to the marketability of harvested periwinkles is also explored. Intertidal surveys within the Menai Strait and Conwy Bay Special Area of Conservation (North Wales, UK) showed that the frequency of oyster-fouled periwinkles was greatest in areas of high adult oyster abundance (Kruskal-Wallis $H = 885.38$, $df = 4$, $p<0.001$) and restricted to large, market-sized periwinkles (>20mm) inhabiting the low shore. Whilst commercial periwinkle collectors appeared to make an active attempt to avoid the collection of periwinkles harbouring large oyster epibionts (>25mm shell length), smaller oysters (as well as a few larger conspecifics) were nonetheless frequently collected accidentally. Survival of all but the smallest oyster epibionts (<5mm shell length; Log Rank $\chi^2 = 257.9$, $df = 3$, $p < 0.001$) under post-collection refrigerated conditions (see Figure 1) enhanced the possibility of accidental non-indigenous oyster transfers. Whilst the survival of fouled and unfouled periwinkles was comparable under post-collection refrigerated conditions, a significant decrease in both mobility ($\chi^2 = 13.572$, $df = 2$, $p = 0.001$) and flesh content ($t = -3.30$, $df = 60$, $p = 0.002$) was associated with the presence of oyster epibionts. Better interventions during both initial visual inspection and post-griddling stages are recommended, as well as the development of techniques that kill off all non-indigenous epibionts, whilst leaving the freshness and marketability of the periwinkles uncompromised.

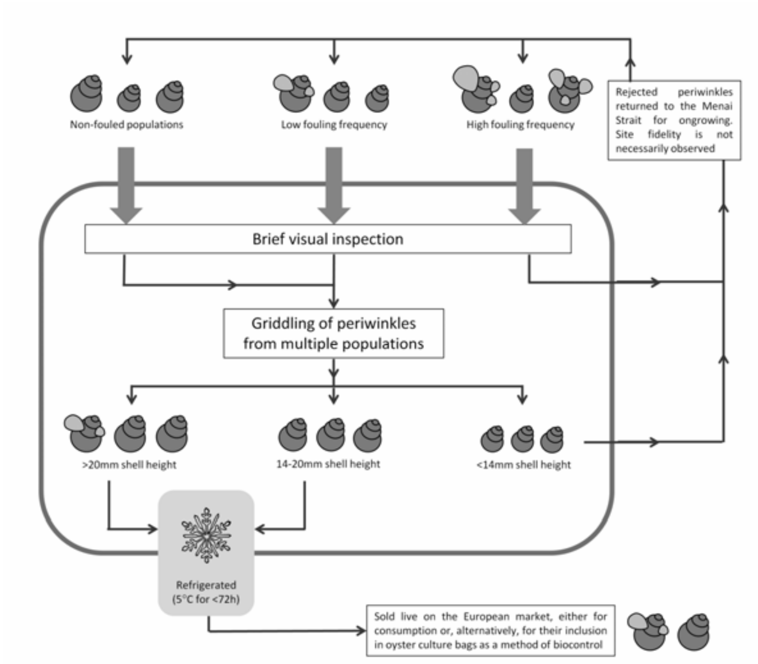

Figure 1. Schematic diagram depicting the commercial harvesting process of the common periwinkle (*Littorina littorea*) in the UK. Activities within the rounded-edged box represent those which occur within a typical wholesaler facility (taken from Morgan and Richardson in press).

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Habitat and distribution of the exotic marine invertebrates in Galicia (NW Iberian Peninsula)

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Despite the magnitude and seriousness that the introduction of exotic marine species involves, these had not been studied in the Iberian Peninsula until recently. The existing data on the aquatic environment belong above all to the continental area, whereas the information on the marine environment is much more limited and practically reduced to the Mediterranean coast, particularly to the impact caused by the alga *Caulerpa taxifolia* on the rich native ecosystems of *Posidonia oceanica*.
Galician coastal systems represent a paradigm of natural variability but also of disturbance of antropic origin. Along its 1.720 km-long coast, Galicia has a total of 128 ports, where activities related to fishing and gathering of shellfish are carried out. In 8 of them, commercial activities are also carried out and 22 coastal communities dispose of sport and marine facilities.
There are different causes for the introduction of marine species in Galicia, such as ballast water or fouling on ships and sport vessels, but the main cause is the import of species for aquaculture and commercialization *in vivo*. Many of these species carry fauna which settles in Galicia under similar favourable conditions to the origin habitat. In other cases, species introduced in our neighbouring countries, end up expanding their distribution area to our coasts.
Some of these species are imported from places as distant as Japan and, in other cases, despite being autocthonous species cultivated in other places, they introduce exotic species by carrying allocthonous fauna.
Some recently published studies have recorded a low number of marine species, if recording any. As for the records of Galician exotic marine species, they can be mainly found in general taxonomical studies and, less frequently, in studies on these species. Regarding other studies, it is worth mentioning the records of the studies by Martínez & Adarraga (2006a, 2006b): 6 species; Arronte *et al.* (2006): 10 species; Bañón *et al*. (2008), who mentions the presence of 19 species of molluscs introduced in our coasts, and Souto *et al.* (2008) who adds *Stramonita haemastoma* to the previously mentioned species.
In order to mitigate this lack of knowledge and its dispersion in different publications as well as to clarify some wrong records, this paper presents a verified inventory of 39 Galician exotic marine species by gathering the information about their habitat and geographical distribution (native and introduced) as well as the possible reasons for their introduction in Galician waters.

Introduced marine non-indigenous species in Portuguese estuaries and coastal areas: who, where and how?

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The introduction of non-indigenous species (NIS) that might become invasive in marine and estuarine ecosystems has increased mainly with globalization and is an issue of global concern due to severe impacts such as biodiversity loss and serious damage to economy and health. Similarly to other European countries, records for NIS in the Portuguese coast have been gradually published but systematic registers or databases and characterization of major pathways were not available. The major objective of this study was to provide a list of NIS registered in Portuguese coastal and estuarine waters and to identify potential introduction vectors. A comprehensive literature review was carried out for NIS registers, including mainland Portugal and the Azores and Madeira islands. Sampling surveys on phytoplankton, zooplankton, macroalgae, benthic and nectobentic invertebrates were conducted on soft and hard substrates nationwide, including potential areas of occurrence of NIS, namely major national harbours, recreational marinas with international traffic and neighbouring areas. A list of 81 aquatic NIS was registered for the Portuguese estuarine and coastal aquatic systems. The Azores islands and the Tagus estuary, where important harbours and recreational marinas are located, were the areas with the highest number of NIS records, confirming that shipping is the most important vector of introduction in Portuguese ecosystems. The barnacle *Austrominius modestus*, the bivalve *Corbicula fluminea* and the macroalgae *Asparagopsis armata* were the most widespread species and are, in general, the dominant species in locations where they were registered. Although most NIS are native from the Indo-Pacific region, shipping movement at Portuguese ports is mainly national and from European countries, indicating that most NIS were secondary introductions. This first national assessment provides an important support for the development of management strategies focused on NIS.

Paracaprella pusilla Mayer 1890, a new alien crustacean in the Mediterranean Sea

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Paracaprella pusilla, originally described by Mayer (1890) from Brazil (type locality: Rio de Janeiro), is one of the most abundant caprellid amphipod species along the Caribbean coast of Venezuela and Colombia. Since its original description, it has been reported from numerous widespread locations in tropical and subtropical seas around the world, primarily associated with fouling communities in harbors but also in intertidal rocky shores. In September 2010, the species was found for the first time in European coastal water, in the Strait of Gibraltar, very close to the western boundary of the Mediterranean Sea. Only one year later, in November 2011, during a survey of amphipod crustaceans from marinas along the coast of Mallorca (Balearic Island), we found many individuals of *P. pusilla* in the marina of Palma, located in the south west coast of Mallorca. The species was found in the fouling community of floating pontoons and ship hulls, mainly associated with the hydroid *Eudendrium racemosum* (Cavolini, 1785). This record represents the northernmost location of the species, which is found for the first time in the Mediterranean Sea. Its most probable introduction vector was ship fouling. Taking into account that the occurrence of *P. pusilla* in the western Mediterranean may be the result of a secondary spread of the species from the recently establish population of the Strait of Gibraltar, the monitoring of this population is very important to avoid a probable future invasion along the whole Mediterranean Sea.

Quantifying ecological novelty in biological invasions

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In invasion research, there is still no general understanding of why some invasions fail while others succeed. Hypotheses proposed so far mainly apply to specific invasion cases only, e.g. enemy release (Maron and Vilà 2001; Keane and Crawley 2002) and novel weapons (Callaway and Aschehoug 2000; Callaway and Ridenour 2004).

To reach a more general, integrative explanation for variation in invasion success, it seems promising to adopt an eco-evolutionary perspective. From this point of view, invasions are characterized by the fact that species reach areas where they have not evolved, which leads to ecologically novel biotic interactions. It is reasonable to expect this ecological novelty to have a significant effect on invasion success.

This leaves us with the need to quantify ecological novelty. It is assumed here that the degree of ecological novelty in an invasion varies according to the experience of the involved species with each other□s traits. Such experience may have been accumulated in previous ecological interactions during evolution of individual species (□eco-evolutionary experience□). The eco-evolutionary experience of a species facing a new interaction partner will be higher if the ecological traits of the latter are more similar to those of previous interaction partners. Thus, ecological similarity may be taken as a proxy for quantifying eco-evolutionary experience. Similarity is often simply assumed to be proportional to the phylogenetic relatedness of the species, as assessed on taxonomic grounds. However, this approach has limitations. Therefore, the development of alternative methods for quantifying ecological similarity is necessary. They may be based on mechanistic reasoning as well as on extensive comparisons between large numbers of traits that are potentially relevant to invasion, as presented here. Differences between ecological interaction types (predation, competition, facilitation) should be considered.

Finding ways of quantifying ecological novelty will be of substantial value for researchers of all related fields (e.g. invasion ecology, GMOs, climate change, restoration ecology) to assess (and predict) more reliably effects, risks, and future developments of novel organisms in changing environments.

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Fitness advantages of specialization

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Most animals do not feed on all the resources available to them, but the mechanisms behind the evolution of dietary specialization are still debated. A central, but unanswered question is whether specialists generally gain fitness advantages on their resource compared to generalists, creating a trade-off between the ability to use a broad range of resources and the fitness reached on each single one. However, empirical tests so far are restricted to few species and results are equivocal. In order to investigate if establishment success, a measure of total fitness, is higher in specialized species, we used a large dataset of intentional biological control introductions of 351 species of parasitic and herbivorous insects from 43 families to locations outside their native range. We show the existence of fitness trade-offs in parasitoids; in this species-rich taxon, species with a restricted diet breadth establish better, indicating that fitness advantages are generally involved in the evolution of dietary specialization. Preliminary results concerning herbivores though do not suggest any obvious trade-off. Implications of these findings for the evolution of specialization are discussed.

Allelopathy in *Fallopia sp*. – a factor in success or a curse?

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The hypothesis AARS (Allelopathic Advantage against Resident Species) assumes that populations invading a new region of occurrence can evolve greater concentrations of allelopathic, defence or antibiotic biochemicals than populations of the same species in their native range (Callaway & Ridenour 2004). These types of substances are found for example in invasive species of *Fallopia* which in their secondary range reproduce mainly vegetatively (Fan *et al*. 2009, Moravcová *et al*. 2011). Few seedlings from this genus have been recorded in Europe and the United States. Sexual reproduction is rare in these taxa, but another cause of this phenomenon may be the action of the allelopathic substances found in their tissues on seed germination.

In our study we assessed potential phytotoxic effects caused by different parts of these plants affecting the germination of their own seeds. The experiment was conducted under greenhouse conditions (19ºC, 14h light) for three taxa of *Fallopia* (*F. japonica*, *F.* ×*bohemica*, and *F. sachalinensis*). We have made two types of experiments to test the effect of these substances. In the first we used rhizomes placed in garden soil while in the second we applied prepared aqueous extracts from knotweed leaves (2.5%, 5% and 0% as control).

The allelopathic effect of leaf extracts on seed germination seed was not considerable. However, in most cases we observed that these extracts did inhibit germination compared with the control samples. We found a pronounced phytotoxic effect of rhizomes of *F.* ×*bohemica* and *F. sachalinensis* on the seeds of all tested taxa. This type of correlation was not found for *F. japonica*.

Our results demonstrate the potential allelopathic effect of invasive knotweed on the germination of their own seeds which may be one of the reasons for the limited number of seedlings in the field.

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The role of allelopathy in *Heracleum mantegazzianum* invasion

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According to the novel weapons hypothesis allelopathy may facilitate invasions of exotic plants especially if the newcomer's biologically active compound meets nonadaptated native species (Callaway and Ridenour 2004). Although an increasing attention has been paid to allelopathy as an invasion mechanism during last decade, only a small number of invasive species were assesed for their phytotoxic effects in ecologicaly relevant conditions.

Heracleum mantegazzianum (giant hogweed) is one out of ten most troublesome invasives in Europe, drastically reducing the biodiversity and through its sap containing photodermatitic furocoumarins being dangerous even to animals and people. Surprisingly, the role of allelopathy in its invasion has been overlooked so far. It remains also unclear whether phytotoxicity in *Heracleum mantegazzianum*, if proved, is due to novel compounds, or rather due to compounds produced also by close native relative *Heracleum sphondylium*.

Here the root exudates collected of both *Heracleum* species toghether with control were assayed for phytotoxic effects on germination and growth of native species common in the invaded biotops. Not only *in vitro* but also in soils that were either sterilized or inoculated with soil biota with or without the addition of activated carbon in all combinations. In addition to bioassays, attempts to indentify the active compound/s by means of chromatografic methods coupled with mass spectrometry are being developed.

In vitro, root exudates of *Heracleum mantegazzianum* consistently decreased root length of most study species. In soils, the allelopathic effects were species-specific and interacted with soil biota presence. Moreover a stronger effect of *Heracleum mantegazzianum* was observed in comparison to the effect of *Heracleum sphondylium.* In order to understand processes interfering with allelochemicals in soil another bioassay and also screening of the soil biota communities at invaded sites are needed.

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Germination and relative growth rate of two annual plants invading river corridors. Does seed heteromorphism matter?

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Trait characteristic associated with invasiveness are one of the fundamental topics of invasion ecology. Recent works have proved that features like germination or relative growth rate play an important role in plant invasion of many species (Grotkopp, Rejmánek 2007). Dissimilarities were observed between species of different biology, phylogeny, or habitat preferences (Küster *et al*. 2008). Moreover only few of the studies have compared relative growth rate (RGR) of invasive species with seed polymorphism, though different seed morphs may contrast in ecological characteristic (Mandák 2002).

The study is aimed to investigate differences in germination and relative growth rate of different morphs of seeds of *Bidens frondosa* and *Xanthium albinum* – alien plants co-occurring and spreading in riparian habitats in Central Europe. Both of the selected species are annuals, reported as invasive and displacing native plant species (Brändel 2004; Tokarska-Guzik *et al*. 2010).

Seeds of both species were obtained from 11 and 22 locations respectively for *Xanthium albinum* and *Bidens frondosa*. Sampling plots were located on river banks of two Central-European river systems: Elbe and Odra rivers with their tributaries: Saale and Warta.

Seeds were collected in September 2011. Dry storage lasting for 4 months was followed by two months length of cold stratification at 5°C in moist conditions. After the stratification period seeds were germinated in Petri dishes in 10/15°C and photoperiod of 12/12 hours. For every collected sample three repetitions of 50 seeds per dish were arranged. The germination experiment was conducted for three weeks. During the germination peak 15 seedlings were randomly collected from each sample and planted separately in a greenhouse. We measured relative growth rates (RGRs), plant biomass production, and specific leaf areas (SLAs) three times in seven-day intervals.

Obtained results will give an insight into relations between seed heteromorphism and differentiation of germination and seedling growth of annual invasive plants, adapted to disturbed habitats like river banks. Different germination patterns, growth rates within and between the species will be discussed. The first results will be compared with information from the literature.

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Sexual and asexual reproduction traits among cytotypes and floral morphs of *Oxalis pes-caprae* invasive populations

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Biological invasions comprise significant ecological and evolutionary consequences, both for the communities being invaded and for the invasive species themselves. 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 mechanisms of plant invasions and predicting microevolutionary changes in anthropogenic environments.

Oxalis pes-caprae L. (Oxalidaceae) is a native species from southern Africa that is currently an invasive weed throughout Mediterranean climate regions worldwide. In its native habitat, this species has been described as heterostylous (with short-, mid- and long-styled flowers), reproducing sexually and asexually and having different ploidy levels (2*x*, 4*x* and 5*x*). In most invaded areas, strong founder events lead to the introduction of the 5*x* short-styled morph only, which reproduces asexually through bulbils. However, in the Mediterranean basin, the three floral morphs and the 4*x* cytotype have been recently found, either by multiple introductions or by their emergence in this region, enabling sexual reproduction; in addition, a sterile form as been reported and is apparently spreading rapidly. Still, there is no study assessing the contribution of asexual and sexual reproduction for the invasion success of this species.

The objective of the present study is to assess evolutionary shifts in of both asexual and sexual reproduction traits between floral morphs and cytotypes and between native and invasive populations of *O. pes-caprae* that may help explaining the invasion dynamics of this species. For this, comparative studies of phenotypic characters directly linked with reproduction are being developed using plants from native and invasive populations and taking in consideration floral morphs and cytotypes as variables. Plants of different morphs and cytotypes were grown in a common garden experiment in the greenhouse and the following variables were quantified: number of leaves, inflorescences and flowers per plant, flowers weight per plant, fruit and seed production after legitimate pollination and number of bulbs produced. Here we present data on the reproductive traits for the three floral morphs and the two cytotypes found in invasive populations from western Mediterranean basin. Plants from native range are currently growing for subsequent comparisons between native and invasive populations. The information gathered adds significant background information on the biology and evolutionary processes of biologic invasions. The knowledge of the probability and speed at which local adaptation evolves in invasive plants is particularly important for management practices, especially when evolutionary changes enhance ecological opportunities and invasive spread.

Plant invasion and species traits across habitats in Cantabric rivers

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Riparian ecosystems are considered to be highly prone to invasion by alien plants, due to their dynamic hydrology, their role as conduits for efficient propagule dispersal, their nutrient and water conditions and the intense disturbance regimes they experience (Pysek & Prach 1993, Vilà *et al*. 2007). Human-driven degradation such as channel modifications and flood regulation or drainage were intensified in the last decades and, as a result, diversity and abundance of alien plants have increased in riparian zones throughout the world (Richardson *et al*. 2007). However, the invasibility of a particular ecosystem is not the only thing to take into account to assess the invasion process: species invasiveness is also of capital importance (Richardson & Pysek 2006). In this work we are looking for relationships among the species attributes and their invasion success across several riparian habitats. Our aims are: 1- to analyze the relationship among species traits and the general invasion success; 2- to test if there is any preference among alien species for the different riparian habitats; 3- in that case to analyze the relationship among species traits and any particular invaded habitat.

We have conducted the survey in cantabric rivers of the eastern half of the Cantabric fringe, in the north of the Iberian Peninsula. 20 sampling sites were randomly sampled along cantabric basins. All native and alien species present in a 100 m long strip were recorded. For alien plants the total abundance in the site and in different riparian habitats were also recorded, according to a 9-index scale. Species traits have been extracted from BiolFlor database (Kühn *et al*. 2004).

The frequency and abundance data of alien species in each riparian habitat will be analyzed by means of fidelity indices and multivariate analysis in order to test their habitat preferences. The invasion success, measured as the frequency and abundance of each alien species in the sampling sites, will be analyzed according to the attributes of these species: life form, dispersion, etc. To test if there is any relationship between traits and invasion success variance analysis and correlation analysis will be carried out for qualitative and quantitative traits respectively. Contingency tables will be constructed to test the correlation among species attributes and riparian habitats.

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Increased population growth in invasive polyploid *Centaurea stoebe* in a common garden

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Biological invasions are inherently demographic processes, but trait differences between native and introduced genotypes are rarely linked to population growth rates. The native European plant *Centaurea stoebe* occurs as two cytotypes with different life histories: monocarpic diploids (EU 2x) and polycarpic tetraploids (EU 4x). However, in its introduced range in North America so far only tetraploids (NA 4x) have been found. Using a novel experimental common garden approach with artificial populations, we compared the demographic performance of the three geo-cytotypes (EU 2x, EU 4x, NA 4x) in the presence and absence of the specialist root-mining insect herbivore *Agapeta zoegana*. With data collected over a period of three years, we parameterized periodic matrix models and conducted elasticity analyses and life table response experiments (LTREs). We found no difference in population growth rate between the two European cytotypes and no significant effects of herbivory in all geo-cytotypes. However, there was a pronounced increase in population growth rate for North American compared to European tetraploids due to increased seed production and juvenile establishment. These results suggest that genetic drift or rapid evolution, rather than pre-adaptation through polyploidy may explain the invasion success of tetraploids.

Reproductive characteristics related to invasiveness in *Ambrosia artemisiifolia*

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Ambrosia artemisiifolia, native in North America, was unintentionally introduced to Europe in the 19th century. In terms of negative impact on human health, agriculture and biological diversity it is at present one of the most noxious invasive plants in Europe. It was first reported from the Czech Republic (CR) in 1883, and now it is recorded in 64 out of the total of 679 grid cells of the Central-Europaean phytogeographical mapping grid. Further spread of the species is highly probable due to ongoing climatic changes and increasing propagule presure, resulting from rapidly increasing abundance in European countries.
Ambrosis artemisiifolia is an annual depending on seed reproduction for population regeneration. Detailed knowledge of its reproductive characteristics is therefore a key assumption for this species' management and control. To identify the traits associated with the invasiveness of alien species we measured reproductive traits of 93 neophytes with different invasion status (invasive or naturalized; Moravcová *et al*. 2010) and compared them with the traits of *A. artemisiifolia*. Invasive species have longer and heavier seeds than non-invasive and produced more propagules. The seed production of *A. artemisiifolia* was below the means of both invasive and naturalized species while its seed length was comparable with those of invasive. In addition, *Ambrosia* has lighter diaspores than the average value in both groups of neophytes. The seeds of *Ambrosia* can be dispersed attached on animal fur or feather as well as by humans, and are highly germinable after braking physiological dormancy. Compared to other neophytes tested, *Ambrosia* has rather high seedling RGR. Seedling growth and development in *Ambrosia* are influenced by temperature and nutrient levels. The seedlings grow faster and taller under higher temperatures. Under low nutrients they grow slower and allocate more biomass into roots. Under optimum nutrient availability (50% of Knopp solution) the low developmental threshold (LTD; the temperature below which the development ceases) was 5.7°C and sum of effective temperatures till the appearance of the 5th leaf (SET; the amount of heat above LTD needed to complete the developmental stage) was 270.3 degree days (DD), i.e. 24.8 and 29.4 days for the warmest and coldest CR region according to the June temperature, respectively. Compared to 19.7 days calculated for Hungary (Budapest), this indicates that the spread of *A. artemisiifolia* in CR may be currently limited by slow development restricting its successful reproduction to the warmest regions (southern Moravia and Labe river lowland). Therefore, its invasion is likely to accelerate in the future as the temperatures increase.

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Local adaptation of invasive alien *Impatiens glandulifera* to contrasting habitats?

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Many invasive alien species are observed under different climatic conditions and in deviating plant communities compared with their native range. Potential adaptation to local environmental conditions might explain differences in habitat invasibility with some consequences for control of the species.

A prominent invasive alien plant species in Europe that is occurring in contrasting habitats is the east-Asian annual *Impatiens glandulifera*. In southern Bavaria, this species is observed in alluvial forests, on fallow meadows and in spruce plantations. These habitats differ greatly, especially with regard to soil acidity, light availability and competition.

In this study we investigate whether *Impatiens glandulifera* is locally adapted to these habitats. If local adaptation has occurred, we expect to find greater variation between than within habitat origins when exposed to treatments representing the main differences between habitat types. If not, performance should be comparable across origins. This hypothesis is tested in a greenhouse experiment. First, we characterized seed material collected from 15 source populations representing the three mentioned habitats on a local scale. We found that seed origins differed significantly with regard to dry mass (Figure 1; ANOVA, $P > 0.05$), although this did not translate to higher germination in heavier seeds (Figure 2). Second, we performed a greenhouse experiment with 600 pots. We included eight treatment combinations, i.e. high/low shading, with/without competition and high/low pH-values. Preliminary results indicate better performance of all plant origins under low shading and without competition. More detailed results will be presented on the poster.

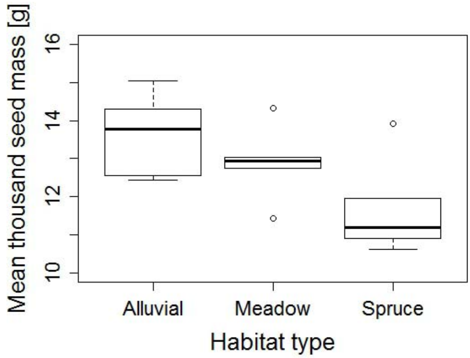

Figure 1. Mean thousand seed mass of seeds from five populations per habitat type.

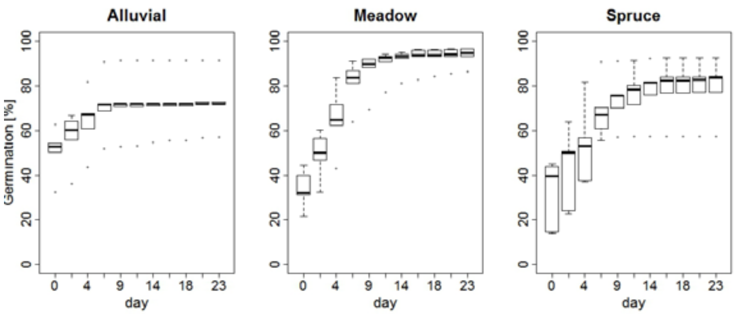

Figure 2. Mean germination of stratified seeds of five populations per habitat type. Germination on wet filter paper in Petri dishes stored at 5 °C (12 h) and 15 °C (12 h) was observed three times a week for a period of 23 days.

Release and constraints at different scales - a framework for understanding the role of evolution in plant invasions

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Attempts to find a consensus on traits promoting the invasiveness of exotic species have primarily agreed on the idiosyncrasy and context-dependency of successful plant invasions. Despite considerable efforts over the last decade to integrate aspects of context-dependency into theories of mechanisms of invasions, none of them has taken a comprehensive evolutionary perspective and provided scale-overarching explanations at the same time. Applying the filter theory of species sorting, I suggest a framework of different filters at different scales explaining evolutionary changes during invasions. Within this hierarchical approach, the focus is on the factorial filters climate, abiotic environment and biotic environment, the latter distinguishing between trophic interactions and plant-plant interactions.

In a first step, the presentation summarizes the evidence of directional shifts from native to exotic ranges, thereby differentiating the direction of shifts with regard to situations of either ‘constraints’ or ‘release’ within hierarchical levels. While evolutionary responses to increasing constraints during plant invasions normally follow purifying positive selection, evidence is also provided that situations of release can be met by relaxation mechanisms allowing for evolution of adaptive phenotypic traits without positive Darwinian selection (Hughes 2012). Following this systematic approach of differentiation, the present frame identifies research gaps that have not been comprehensively addressed to date.

In a second step, the focus is on interacting effects of hierarchical factors on the role of adaptive evolution during invasions by highlighting examples of trade-off situations across factors and hierarchical levels. More beneficial situations with regard to one factor acting as filter may afford adaptations to less favourable situations with regard to another factorial level. While some of these trade-offs have already been coined and have yielded in repeatedly tested hypotheses, such as the *evolution of increased competitive ability* hypothesis (EICA, Blossey & Nötzold 1995, Bossdorf *et al*. 2005) or the *resource-enemy release hypothesis* (Blumenthal 2005), others have not been explicitly addressed to date.

The present review predicts research attempts to complement the understanding of context-dependency of plant invasions. As a main outcome, the frame suggests that, in particular, the role of climatic changes should more explicitly be linked with evolutionary responses during invasions. In addition, studying exotic species successfully invading multiple regions with different environmental conditions will be a promising starting point to enlarge the understanding of context-dependency of invasions.

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Metabolic differences between native and invasive populations of *Bunias orientalis* and its implications on herbivores and their parasitoids

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The chemical composition of a plant can vary to a high degree between plants of native and invasive populations and thus may affect not only the performance of herbivores but also of their antagonists. We compared the chemical composition of various populations of native, exotic (range-expanding) and invasive populations of *Bunias orientalis* (Brassicaceae) and investigated the development of the generalist herbivore, *Mamestra brassicae* (Lepidoptera: Noctuidae), and its solitary endoparasitoid, *Microplitis mediator* (Hymenoptera: Braconidae), on these plant populations. *Bunias orientalis* is a range expander, originally from SE-Europe and SW-Asia, which has become invasive in central and northern parts of Europe in the last three decades (Harvey *et al*. 2010). Although it invades communities, where native species of Brassicaceae grow, several specialist herbivores in these communities are not able to develop on this plant (Travers-Martin & Müller 2008; Kühnle & Müller 2009) and only few generalist herbivore species can cope with the plant defences (Harvey *et al*. 2010). The metabolic fingerprints of the plants could be clearly separated by their origin. The predominant metabolite in *B. orientalis*, *p*-hydroxybenzyl glucosinolate (sinalbin), was significantly higher in concentration in plants of the invasive and exotic than of the native origin. This is in accordance with the shifting defence hypothesis (SDH) (Doorduin & Vrieling 2011), which predicts that the concentration of characteristic defence compounds is higher in plants of the invasive range, if their biosynthesis does not involve high costs. Furthermore, the survival of *M. brassicae* and *Mi. mediator* was significantly affected by *B. orientalis* plant origin. The herbivore larvae and their parasitoids survived better on plants from both exotic and invasive range, compared to those growing on the native populations. Pupae of *M. brassicae* also reached a larger biomass and developed faster on the invasive populations than on the native populations. These performance parameters do not correlate with the concentration of sinalbin in the plants. Thus, the reduced survival of this herbivore and parasitoid on plants from the native range must be explained by the increased presence of other allelochemicals including digestibility reducers or mechanical defences, such as trichomes in these plants. Overall, this native generalist herbivore provides biotic resistance to plant invasion, but the top-down regulation by its natural enemies (e.g. parasitoids) might facilitate the spread of *B. orientalis* in its invasive range.

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Changing hierarchy in size traits during ontogeneses and due to environment

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Invasiveness of many alien plants is associated with their traits. Despite considerable plasticity and local differentiation, traits used in comparative studies are often measured under one and often not identical environment and only adult individuals are involved. Influence of environment and ontogenetic stage on plant traits was investigated by comparing four *Impatiens* (Balsaminaceae) species occurring in Central Europe: native *I. noli-tangere*, highly invasive *I. glandulifera*, less invasive *I. parviflora*, and potentially invasive *I. capensis*. Using closely related species we avoid phylogenetic and due to the overlapping niches also habitat biases. We investigated two size traits, shoot biomass and plant height of seedlings and adults in response to simulated canopy shade, water and nutrient levels and also under competition, and found considerable differences in the size hierarchies. *Impatiens glandulifera* had usually the highest biomass except seedlings under simulated canopy shade and adults under combination of deep shade, high moisture and competition. On the other hand, the seedling height was comparable with the other species except under simulated canopy shade. Adults of *I. glandulifera* were always the tallest. Large differences between positions of seedlings and adult were found in *I. parviflora* and *I. capensis*, with the first having large seedlings and the last large adults but only without competition which strongly decreased the plant size under water limitation. Success of *I. glandulifera* may be attributed to the large size of adults, but this seems not to work with the other species. Success of *I. parviflora* seems to be due to the large seedlings and good performance of adults under competition under water limitation. On the other hand, spread of *I. capensis* which seems to be highly invasive due to large adults is probably limited due to small seedlings and poor performance under competition and water limitation. We conclude that performance throughout the life cycle and across environments including plant competition should be taken into account in considering plant invasion potential.

Alien species of *Conyza* Less. in Europe

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There are 7 alien species in Europe – *Conyza canadensis* (L.) Cronquist, *C. bonariensis* (L.) Cronquist, *C. sumatrensis* (Retz.) E.Walker, *C. floribunda* Kunth., *C. blakei* (Cabrera) Cabrera, *C. bilbaoana* J. Remy & *C. triloba* Decne.

In 2009 biomorphological characters and competitive ability of two species in the genus *Conyza* Less were under investigation. The biometric traits *of C. sumatrensis* and *C. canadensis* were comparatively analyzed in the invasive populations within the area of Eastern Mediterranean basin. Number of heads was the most variable trait in both species: it varied from 8 to 424 (CV = 69%) in *C. sumatrensis,* and from 25 to 315 (CV = 48%) in C *canadensis.* Lengths of head envelope and head diameter were the least variable traits, and in *C. sumatrensis* they were 1,3 times more than in *C. canadensis. C. sumatrensis* has several competitive advantages over *C. canadensis:* it bears 2 times more diasporas, it is resistant to dry poor soils and intensive light, it repeatedly blooms and fruits during growing season. However seed germination, emergence of seedlings, seedling vigor are better in *C. canadensis.* Plants of *C. canadensis* withstand low temperatures and long light day, and so the range of C. *canadensis* expands towards to the north. Quite possible, the range of *C. sumatrensis* will also continue to advance to the north because of plant adaptation to new environmental conditions and climate wanning. In 2010-2011 four invasive annual species of Europe - *Conyza canadensis, C. bonariensis, C. sumatrensis* and *C.bilbaoana* were cultivated in homogeneous conditions of an experimental plot in Moscow Region. Seeds of *C.bonariensis* have been collected in Lisbon (Portugal), Jerash (Jordania), Famagusta (North Cyprus) and Limassol (Cyprus). Seeds of *Conyza canadensis* have been collected in Primorsky Krai, Sochi, Moscow and in native distribution range (Pennsilvania and Minnesota, USA). Seeds of *C. sumatrensis* have been collected in Porto (Portugal), Suchumi (Abkhazia), Murcia (Hispania), Alcudia (Hispania, Mallorca) and Ko Samui (Thailand). Seeds of *C.bilbaoana* have been collected in Dublin (Ireland). The detailed description of these taxa are given. Though in the nature *C. canadensis*, *C. bonariensis* and *C. sumatrensis* are recognized insufficiently accurately, cultivation of these species in homogeneous conditions allowed to reveal the whole complex of diagnostic characters. Distinctions between species on rate and duration of the growth period, on a phenorhythm, the sizes and the form of leaves, type of runaway's pubescence, on a structure of runaways system, on number, the sizes and the form of heads, and also on a involucre characters are revealed.

Table 1. Some parameters of *Conyza* species at the phase of full blossom (mm)

		C.canadensis	*C. bonariensis*	*C. sumatrensis*
leaves at the base of inflorence	length (l)	58	55	58
	width (d)	3	2	4
	l/d	19.3	27.5	14.5
leaves at the middle part of stem	length (l)	99	71	70
	width (d)	9	6	14
	l/d	11.0	11.8	5.0
leaves at the base of stem	length (l)	87	82	dry up
	width (d)	8	8	
	l/d	10,9	10,3	
heads	length (l)	4,8	6,1	6,6
	width (d)	2,4	5,2	3,2
	l/d	2:1	1,2:1	2:1


a
b
c

Alien species of *Robinia* L. in Europe: flowering patterns & seed production

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Comparative study of flower's structure in three species of *Robinia* L. – *R. pseudoacacia*, *R.* × *ambigua* & *R. neomexicana* – was carried out. 4 samples of *R. pseudoacacia*, 2 samples of *R.* × *ambigua* & 3 samples of *R. neomexicana* were collected in Slovakia and in Moscow.

Invasive *R. pseudoacacia*, in comparison with other species, has the smallest size of flower organs at each stage of flower development. A number of essential taxonomic characters in *Robinia* L., related to flower development stages, was revealed and studied (table 1). The set of characters (both, numeric and non-numeric) comprises microscopic morphological ones in flowers of the *Robinia* species. Flower development stages could be effectively used for defining the boundaries between the floral phases. Additional taxonomic characters (shape of anthers, size and shape of pollen grain, pollen fertility) were revealed and discussed.

R. neomexicana has the biggest pollen grains (35,7×23,2 μm), *R. pseudoacacia* has the smaller ones (31,8×21,2 μm). Both *R. neomexicana* & *R. pseudoacacia* have elliptic pollen grains, their pollen fertility is high – 96-98%. *R.* × *ambigua* has roundish and the most small pollen grains (28,6×22,9 μm); its pollen fertility is low - 38%.

Interpopulation variability of fruits and seeds of *R. pseudoacacia* doesn't demonstrate a clinal pattern (specimens were collected in 16 invasive population from St.-Petersburg (60°N;30°E) to Iraclion (35°N;25°E)). The interpopulation variability is lower than the individual one. The length of beans varies from 2,1 to 10,7 cm (on the average 4-6 cm); width – from 0,3 to 1,7 cm (on the average 1 cm). A fruit consists of 1-16 seed cavities, however a part of seeds remain underdeveloped, and the part is damaged by wreckers; thus, there are only 1-4 viable seeds in the bean. Seed 4,2-5,8 long, 2,9-4,3 mm broad, 18,5-29,1 mg weight. Seeds can be slightly pubescent or glabrous, black or brown, with or without spots. Glabrous brown seeds without spots were often noted (44 %); glabrous brown seeds with black spots were noted less frequent (38 %). Only in 2 populations there are pubescent brown seeds without any spots; once we have noted glabrous black seeds without any spots.

Table 1. Some parameters of a flower at the phase of full blossom, mm

	R. pseudoacacia	*R. neomexicana*	*R.* × *ambigua*
length of flower bud	17,6±0,1	21,8±0,2	20,1±0,2
length of calyx	6,9±0,1	7,3±0,1	7,8±0,1
diametr of calyx	3,5±0,1	4,8±0,1	3,8±0,1
length of calyx's teeth	2,1±0,1	2,3±0,1	2,7±0,0
length of roundish anther (l_1)	0,60±0,01	0,74±0,06	0,53±0,02
width of roundish anther (d_1)	0,52±0,02	0,56±0,13	0,52±0,03
l_1/d_1	1,2	1,4	1,0
length of elliptic anther (l_2)	0,75±0,01	0,76±0,01	0,81±0,02
width of elliptic anther (l_2)	0,51±0,02	0,36±0,02	0,62±0,08
l_2/d_2	1,6	2,2	1,7
length of pistil's stile	7,45±0,13	7,56±0,06	7,84±0,04
length of pistil's ovary	11,34±0,27	15,38±0,14	12,98±0,24
diametr of pistil's ovary	1,00±0,02	1,14±0,02	0,83±0,01

Reproductive biology of Australian acacias in Portugal

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Reproductive traits play a key role in the invasion by exotic plants because successful reproduction in new areas is fundamental for the establishment of self-replacing populations. It has been hypothesized that self-compatible plants have an advantage for the successful establishment in a new range because reproduction is less constrained by population size and pollinator availability; thus, self-compatible plants are expected to be more invasive than obligate outcrossing plants (Baker 1955; Gibson *et al*. 2011).

Australian *Acacia* species have been widely used in forestry and gardening and, as a consequence, landscapes in many parts of the world are now dominated by planted or invasive stands of acacias. Four species of Australian acacias are currently aggressive invaders in Portugal: *A. dealbata*, *A. longifolia, A. melanoxylon* and *A. saligna.* In the native range, these species are mostly self-incompatible and have a clear tendency for outcrossing; however, no information is available about their breeding systems in invaded areas.

In this study, an experiment to assess the breeding system of the four most aggressive invasive *Acacia* species in Portugal was conducted. Floral traits, breeding system and reproductive outcome were characterized in natural populations in this invaded range. Hand pollination experiments, involving pollinator exclusion and supplementary pollination using autogamous and xenogamous pollen were conducted to assess self-incompatibility and pollen limitation. Fruit and seed set, seed mass and germinability, and seedling growth were assessed for self- and cross- pollination treatments. The preliminary results show that *A. longifolia* is a self-compatible species (Index Self-Incompatibility (ISI) = fruit set after self-pollination / fruit set after cross-pollination = 0.19; Zapata and Arroyo 1978) that suffers pollen limitation in this invaded area (Figure 1A); no differences were observed in seed germination between outcross- and self-pollinations but, seedlings from the former pollination treatment had significantly higher growth rates than seedling of the later (based on dry matter). *A. saligna* revealed to be partially self-compatible (ISI = 0.46), with fruit set not limited by pollination services; no differences were observed in seed germination between outcross- and self-pollinations. The data for the other two species are currently being gathered and will also be presented. The preliminary results do not corroborate the hypothesis proposed above as some species maintain its incompatibility system; in addition, despite the low natural fruit set (Figure 1, open pollination treatment), *Acacia* species produce a huge amount of seeds in the invaded range that could be one of the factors involved in its invasions success.

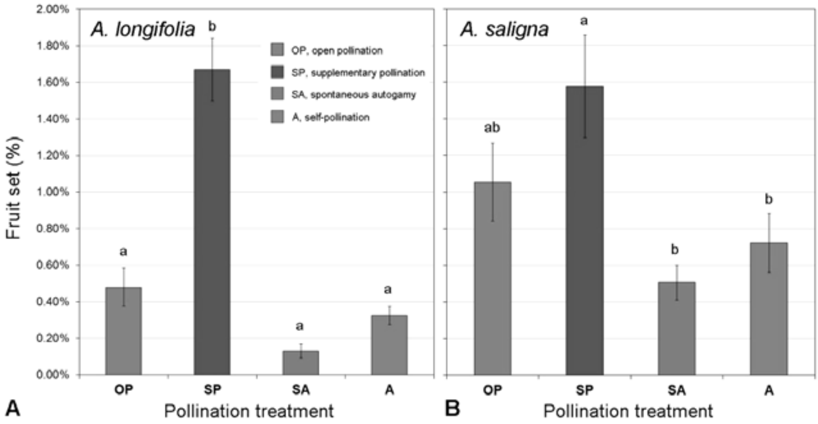

Figure 1. Fruit set from hand pollination experiments in *Acacia longifolia* (A) and *A. saligna* (B). Fruit set was calculated as a percentage of the number of pods from the total number of hermaphrodite flowers treated, and is given as mean and standard error of the mean. Pollination treatments: OP – open pollination; SP- supplementary pollination; SA – spontaneous autogamy; A – self-pollination. Different letters reveal significant differences at *P<0.05*.

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Differences in temporal niche among exotic tree species co-occurring in riparian forest of the Iberian Peninsula.

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Previous studies suggest that phenological differences between native and exotic plant species may help to explain invasive species success, especially if they exploit different temporal niches (Celesti-Grapow *et al*. 2003, Godoy *et al*. 2009). Furthermore, a longer fructifying and seed dispersal period may favour the spread of invasive species in invaded areas (Traveset *et al*. 2008). In this work, we aimed to compare differences in phenology among three exotic (*Robinia pseudoacacia, Ailanthus altissima* and *Ulmus pumila)* and one dominant native tree specie (*Populus alba*) co-occurring in riparian forests of inner Iberian Peninsula. In February 2011, we selected 6-13 adult trees per species in the riverside of the Henares River (Madrid, central Spain). Since then and until February 2012, the frecuency of phenophase occurrence (leaf formation and abscission, flowering, fruit set and seed dispersal) was monthly monitored. The dates of beginning and end and the duration of each phenophase were statistically compared among species (one way ANOVA). We found differences among species in the dates of beginning and end and in the duration of all the studied phenophases, except in the date of leaf-formation (Figure 1). The phenology of the exotic *U. pumila* was closer to that of the native *P. alba*, showing earlier flowering and fructifying, longer leaf life-span and shorter seed dispersal than the rest of the studied exotics (Figure 1). Fruit set of the exotics *A. altissima* and *R. pseudoacacia* was at least four times longer than that of *U. pumila* and *P. alba*. Furthermore, *A. altissima* and *R. pseudoacacia* seed dispersal was observed through the whole year (Figure 1). Our results suggest that the exotics *A. altissima* and *R. pseudoacacia* exploit a different temporal niche than the dominant native *P. alba* for their reproductive phenophases. This fact may help to avoid competition for resources among both groups of species. Besides, the long dispersal period of these two exotics may increase the chances for spread. By contrast, the similar phenology between the exotic *U. pumila* and the native *P. alba* may make them more direct competitors. Therefore, other plant traits should explain the high success of *U. pumila* in this area.

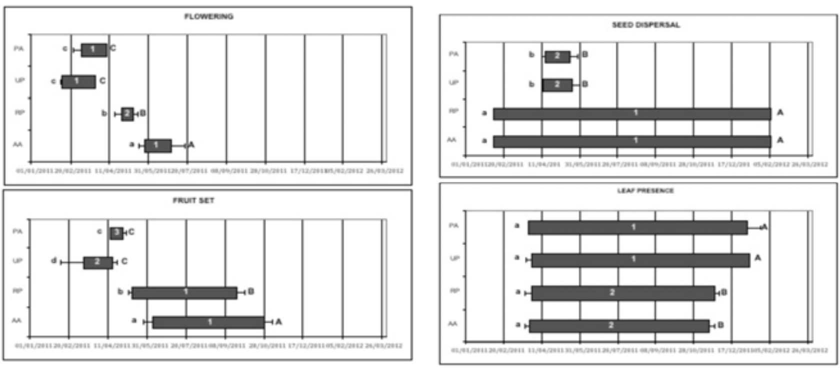

Figure 1. Phenological calendar of exotic and native tree species. Bars are means ± SE. Different lower-case, capitals letters and numbers among species indicate significant differences of beginning, end and duration of phenophases, respectively. Exotic trees are *Ailanthus altissima* (AA) *Robinia pseudoacacia* (RP) and *Ulmus pumila* (UP) and native tree is *Populus alba* (PA).

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Early resistance of alien and native pines against two native generalist insect herbivores: no support for the Natural Enemy Hypothesis

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The Natural Enemy Hypothesis (NEH) predicts that alien plant species might receive less pressure from natural enemies than do related coexisting native plants. However, most studies to date are based on pairs of native and alien species and the results remain inconclusive. The level of attack by native generalist herbivores can vary considerably between plant species, depending on defensive traits and strategies. Plant defenses include preformed constitutive and induced defenses that are activated as plastic responses to herbivore attack. However, the efficacy of induced defenses could be altered when alien species entering an area are exposed to native enemies.
We tested the NEH for several closely related alien and native pines to Europe by examining early anti-herbivore resistance to damage by two generalist native insect herbivores (*Hylobius abietis* and *Thaumetopoea pityocampa);* the differences in constitutive and inducible chemical defenses (i.e. non-volatile resin and total phenolics in the stem and needles); and whether consumption preferences shift after induced defenses have been triggered by real herbivory.
We did not find alien pines to be less damaged by two generalist herbivores than native pines were. The constitutive concentration of chemical defenses significantly differed among pine species. The concentration of constitutive total phenolics in the stem was greater in native than in alien pines. The opposite trend was found for constitutive total phenolics in the needles. The concentration of chemical defenses (non-volatile resin and total phenolics) in the stem significantly increased after herbivory by *H. abietis*. Moreover, the induction of total phenolics by *H. abietis* damage was significantly greater in native pine species than in alien pines. On the other hand, only concentrations of non-volatile resin in needles significantly increased after herbivory by *T. pityocampa*, but without significant differences in inducibility between alien and native pines. In cafeteria bioassays, *H. abietis* consumed the twigs from alien more than those from native species irrespective of prior exposure to the insect. Meanwhile, no differences among range origin were found in the *T. pityocampa* cafeteria bioassays.
Overall, we found no support for the NEH in alien pines to Europe. This suggests that alien pines, in regions where they coexist with native congeners, may be controlled by native generalist herbivores, this being one reason that invasion by alien pines is not frequent in Europe.

Notes on the new findings and biology of the alien species *Branchiomma bairdi* (McIntosh, 1885) (Annelida: Sabellidae) from Central Mediterranean

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We provide notes on reproductive biology and ecology of the alien species *Branchiomma bairdi* (McIntosh, 1885) from the Central Mediterranean that can help to understand its introduction and expansion along this area (findings are indicated in Table 1). *B. bairdi* is original from the Caribbean Sea, and recently has been introduced in the S-E Gulf of California (Tovar-Hernández *et al*. 2011), and Turkey and Cyprus in the Mediterranean (Cinar, 2009). This first finding in the Mediterranean was relative to the eastern basin, but probably the species was already present also in the west Mediterranean and misidentified with *B. boholense* (Roman *et al*. 2009; A.Giangrande pers. obs.). The diagnostic features between these related species are the macrostylodes shape and the thoracic uncini teeth. The re-examination of specimens collected from Miseno habour (Gulf of Naples, Italy) revealed the presence of *B. bairdi* in the central Mediterranean since September 2004. Currently, the species has been spreading along different Mediterranean areas (Table 1).

Several specimens of *B. bairdi* collected alive from Malta, were brought to the laboratory to carry out a preliminary study of their reproductive biology. This simultaneous hermaphrodite species, develop separately but in the same segments male and female gametes. The oogenesis is asynchronous and the oogonia and earlier oocytes mature associated with small blood-vessels that irrigate the lateral coelomic cavity. Contrarily, early clusters of spermatogonia arise from the coelomic epithelium arranged in a pair of raceme-like structures located on either side of the dorsal vessel. Mature sperm pass into nephridial chambers being released through the external excretory pores. The presence of these chamber-like modifications may also suggest some sort of sperm storage. The trade-off between egg size and number from Maltese *B. bairdi* population differs from that presented by the non-indigenous population from California (Tovar-Hernández *et al*. 2011). In our population, *B. bairdi* produced less eggs with a larger size, the opposite occurred in California ones.

In isolated specimens, the simultaneous occurrence of mature sperm and oocytes may favour self-fertilization. Furthermore, evidences of asexual reproduction have been found. Several specimens show 4-5 thoracic segments, fewer than the usual 7-8 ones. After Tovar-Hernández *et al*. (2011) when this occurs, worms would reproduce asexually. The specimens with reduced thoracic segments were forming tube-aggregates of 4–8 individuals. While, specimens with usual number of thoracic segments has been found isolated.

B. bairdi seems to be particular abundant in confined and anthropogenic degraded areas. This great capacity to colonize different habitats and substrates (Table 1), combined with the occurrence of multiple reproductive strategies, sexual, asexual, and combination of both, could be a pre-requisite for its high potential of invasion, and may further explain how this sabellid is able to colonize and spread along wide areas in a relatively short time. By the examination of all current findings of this species in the Mediterranean it is also possible that this species, which was hypothesized to have been introduced on the ship's hulls or through the Suez Canal (Cinar, 2009), was introduced through the Gibraltar strait.

Table 1. Summary of the findings of *B. bairdi* in the Mediterranean Sea. low: 1-5 indv/m^2; high: > 15 indv/m^2

Locality /Year	Substrate	Relative abundance*	Depth	Others features	Reference
Miseno habour (Bay of Pozzuoli, Tyrrhenian Sea) Gulf of Naples September 2004	Dead matte of the seagrass *Posidonia oceanica*, densely covered by invasive algae *Caulerpa prolifera*	High	7 m deep	Below the local mussel (*Mytilus galloprovinciallis*) shellfish aquaculture structures	Current work
Mar Menor Lagoon (Spain) January 2006	Rocky bottom	High	Midlittoral 0.2 m deep Infralitoral 2 m deep		Roman *et al*., 2009
Lake of Faro (Ionian Sea) Sycily July 2007	Soft sediments	High	2 m deep	Occurring sympatrically with other sabellids, viz. *Myxicola infundibulum, Branchiomma luctuosum* and *Megalomma lanigera*	Giangrande *et al.,* in press
Cypro harbor July 1998 Iskenderum Bay (Turkey) September 2005	Rocky bottom on *Padina pavonica* Rocky bottom on *Cystoseira*	Low Low	0-1m deep 0 -1 m deep		Cinar, 2009
Castello Aragonese (Tyrrhenian Sea) Island of Ischia July 2011	Dead matte of *P. oceanica,* covered by macroalgae	Low	2 -3 m deep	With CO_2 vents and acidified water conditions	Current work
Port of Gozo (Maltese Island) April 2012	Rocky bottom	Low	Midllittoral 0.5 m deep	Occurring together with a high diversity of invertebrates, viz. the Lessepsian gastropods *Stomatella impertusa* and *Bursatella leachii*	Current work

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Variation in reproduction parameters of an invasive population of round goby from the middle Danube

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The round goby, (*Neogobius melanostomus* Pallas, 1814), originally coming from Ponto-Caspian region, is a non-native species in the middle and upper Danube, as well as elsewhere. The round goby have been documented since 2003 in the Slovak (middle) part of the Danube. Our studies on life-history traits of invasive populations from this area, that have started in 2004, suggest the species' great phenotypic plasticity and flexibility in allocation of sources, i.e. variability in both growth and reproduction (Ľavrinčíková *et al*. 2005, Ľavrinčíková and Kováč 2007). These attributes facilitate its adaptation to different environmental conditions. Therefore in this study, life-history traits of a well established round goby population were examined. The main aims were to: 1) examine inter-annual variability in its reproductive parameters; 2) test the hypothesis that the population will respond to a sudden disturbance by creating one extra spawning batch. The hypothesis predicts that after the disturbance has occurred, the sub-population from the Karlova Ves side-arm (KV) will show significantly higher values of gonadosomatic index than the sub-population from the Čunovo reservoir (CR), as well as that the portion of females with two size-groups of oocytes will be significantly higher in the sub-population from KV than in the sub-population from CR. The disturbance resulted from a sudden rapid increase of water level (>5m) that occurred in KV but not in CR. Materials were collected from KV and CR by fishing rods and electrofishing from late 2008 to 2010. In total, 276 females were examined in 2008/2009 and 413 females in 2010. Significant differences in the reproductive parameters (including the duration of spawning season) between 2008/2009 and 2010 were found (Table 1). As predicted, the values of gonadosomatic index of the population from KV were found to be significantly higher than those of the population from CR (0.13-15.94, mean 3.08 for KV, and 0.15-18.12, mean 3.08 for CR). Similarly, a significantly higher portion of females with two size-groups of oocytes was found in the sub-population from KV than in the sub-population from CR. This means that as a response to the sudden disturbance, the sub-population from KV created one extra spawning batch, in contrast to the sub-population from CR. In conclusion, the results support the hypothesis tested, and address that round goby is a species with high flexibility in life-history traits.
This study was supported by VEGA, project 1/0641/11 and UK grant, project 179/2011.

Table 1. Reproductive parameters of round goby from the Slovak stretch of the Danube

Reproductive parameters	2008/2009		2010	
	range	mean	range	mean
Gonadosomatic index	0.16 - 17.33	1.83	0.10 - 22.84	4.08
Absolute fecundity	548 - 7501	2203	1232 - 22142	5075
Relative fecundity	101 - 1047.3	318.1	224.7 - 3568.9	829
Size of oocytes (mm)	0.04 - 2.56		0.04 - 2.58	

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Reproductive parameters of an invasive population of topmouth gudgeon from a heavily disturbed habitat (PROJECT UK/409/2012)

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Topmouth gudgeon (*Pseudorasbora parva*) is considered a fish with great invasive ability, especially thanks to its high reproductive potential and its overall biological flexibility as well as phenotypic plasticity (Záhorská *et al*. 2012). The present study focuses on testing the hypothesis about the alternative ontogenies and invasive potential of freshwater fishes (Kováč 2010) by analysing reproductive parameters of an invasive population of topmouth gudgeon. The examined population originates from the Kolarovo channel (Bulgaria) and it has been established recently (not more than 10 years). This habitat is considered to be heavily disturbed, because of extremely high water level fluctuations. Material was collected from April to October 2011. A total of 620 specimens (383 females, 122 males, 115 juveniles) were examined. The sex ratio was 3.14:1 (female:male). Standard length (SL) of females ranged from 19.31 to 51.16 mm, and body weight ranged from 0.08 to 3.04 g. The number of oocytes was determined gravimetrically. Absolute number of oocytes varied between 1838 and 11072, whereas, the relative number of oocytes varied between 5409 and 21262. Gonadosomatic index varied throughout the season from 0.31 to 60.85 %. The diameter of 50 randomly selected oocytes was found to range from 0.05 to 1.50 mm. Some topmouth gudgeon from Kolarovo were found to mature at a very small size (<20.0 mm SL), and 100% of individuals were mature at 29.01 – 32.00 mm SL. The reproductive parameters of the studied population are further discussed within the context of the hypothesis of alternative ontogenies and invasive potential of freshwater fishes. This hypothesis predicts that the population from the disturbed habitat will have significantly higher both absolute and relative fecundity and significantly smaller oocytes.
This study was supported by APVV LPP-0154-09 and VEGA 1/0641/11.

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Morphological variability in pumpkinseed *Lepomis gibbosus* from different habitats in non-native area of distribution

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Pumpkinseed *Lepomis gibbosus* (L.) is one of the non native fish species in Europe currently established in at least 28 European countries. This North American centrarchid species has demonstrated a great variability in its life history traits in response to different environmental conditions. Increased environmental plasticity tends to assign it to the most invasive fish species and makes it of interest to aquatic ecologists to predict the risk of species introduction. Morphometry belongs to the most easily perceivable means for assessing specie's plasticity. The aim of the present study was to assess morphological differences among 11 non-native European populations from Belgium, Holland, England and France. In total 1031 specimens of pumpkinseed 26 external morphometric measurements including standard length (SL) were examined using image analysis based on digital photographs and the Impor 2.31E software. Tripple regression analysis (TRA) was used to test whether body proportions change abruptly rather than gradually in every population separately. Differences between variables among populations we noted using one-way ANOVA with Tukey HSD post-hoc test to closer determination of differentiate population. Based on TRA we can say that in majority populations is the growth linear without changes. In three populations we found out the isometric growth with abrupt change. This can lead to idea that the body proportions changed during ontogeny. Also, we can say that the traits are significantly different among all populations. Based on all statistical tests, we can predict, that populations from ponds have more similar body proportions to those from streams. One population was completely different, which we can explain with overall bigger SL. It is evident that pumpkinseed is a species with a great morphological variability. It appears that both the adult phenotype and the patterns of development in introduced pumpkinseed can, in general, be highly influenced by local conditions because the morphology and the ecology presented by an organism have been shown to be directly or indirectly under the influence of the environmental conditions that the organism experiences and its heritable composition (Norton *et al*. 1995). Such a great variability is likely to be one of the attributes that make this species such a successful invader. Such a great variability is likely to be one of the attributes that make this species such a successful invader.

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Pollination at home and abroad

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Entomophilous alien plants need to become well integrated in the introduced plant-pollinator network to set seeds and get established. However, it is largely unknown how pollination patterns differ between introduced and native ranges. We compared the identity and abundance of pollinators, insect pollen loads, pollen deposition on stigmas, and fruit and seed sets of Hedysarum coronarium (Fabaceae) in populations from native and introduced ranges in Spain. In both areas Hedysarum was visited by a similar number of species, mainly hymenopterans. Seven pollinator species were common between native and introduced areas. Pollinator richness, abundance and visitation rates were larger in the native than in the introduced range, as well as fruit and seed sets. Hedysarum pollen loads on stigmas and on Apis mellifera, the most common pollinator, did not differ between areas. Lower abundance of pollinators might be causing lower visitation rates, and to some extent reducing Hedysarum fruit and seed sets in the introduced area. Our biogeographical approach has detected that despite the high degree of pollination generalization, plants in the introduced populations are pollen limited and do not attract more pollinators than in native populations.

Pollinator visitation of native and alien plant species

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During the invasion process, alien species overcome several geographical and reproductive barriers, and undergo different stages. Naturalization is a crucial stage towards becoming invasive. Many alien plant species establish naturalized populations in new regions without their usual pollinators, and some become invasive. Recent studies have shown that many naturalized alien plant species are capable of attracting native pollinators. However, it is not known whether alien species that did not establish naturalized populations are less successful in attracting pollinators. Here we tested whether naturalized alien plant species have similar pollinator visitation rates as native species, and whether non-naturalized alien species have lower pollinator visitation rates. To this aim, we conducted a multispecies comparative study of pollinator visitation on 446 native and alien plant species in the Botanical Garden of Bern, Switzerland. After correction for phylogeny, we found that, overall, non-naturalized alien species received fewer pollinators than naturalized alien and native species. However, pollinator visitation duration, pollinator diversity, and visitation by bees, did not depend significantly on plant species status. Our results indicate that successful naturalization of alien plant species might depend on the capacity to attract native pollinators.

Do disturbances change the altitudinal distribution of native and non native plants in the eastern cordillera of Ecuador?

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Most studies on species invasions in mountain regions have been conducted in temperate regions, or subtropical islands. This study analyzes the altitudinal distribution of native and non-native plant species along an altitudinal gradient in a tropical continental region, considering presence of disturbances. The main objectives were to determine and compare the altitudinal distribution patterns of native and non-native species, and to determine if distance from the road (a surrogate of disturbance) affects richness and location of native and non-native along the altitudinal gradient. The research was conducted on a road located between 1150 to 4000 m a.s.l., in the eastern cordillera of Ecuador. We established 20 transects "T-shaped", each 150 m a.s.l., with one side parallel to the road (subtransect *edge*) and a perpendicular side (subtransect *near* and *far* to road). Within each "T" species were recorded, habits, native or non-native status and intensity of disturbance (undisturbed, disturbed and very disturbed). The relationship between altitude and distribution of native and non-native species were analyzed with linear and non-linear regression models. We used these models to study the distribution patterns of native and non-native species in relation to distance from the road (disturbance) and altitude. The differences in species richness with relation to distance from the road, and altitude, were evaluated with ANCOVA to native species and a t-test (using data from the parameters of quadratic equations) to non-native species. The similarity of species composition in habitats *near* and *far* to the road was analyzed with Chao-Jaccard abundance based and Jaccard classic.

We recorded a total of 728 native and 43 non-native species. All species declined with the elevation. Native species always showed a monotonic linear decrease with elevation (except on *edge*), while non-native species always showed a quadratic relationship (Figure 1).

Subtransects along the road side had higher intensity of disturbance, and showed higher richness of non-native species and lower richness of native species. The opposite was found on distant subtransects. There was a variation on the similarity of species composition between *edge* and far transects, the *edge* transects were more similar along the elevation gradient. We conclude that in a tropical highland continental, native species and non-native species respond differently to altitude, native plants decrease monotonically, while non-native plants follow a unimodal trend. Along the gradient, disturbance mainly affects non-native species, and very little to native species; in more disturbed areas, *edge,* the number of non-native species increase and tends to be more similar the species composition. Funding provided by SENESCYT, Chilean Ministry of Economy, FICM P05-002 and CONICYT PFB-023.

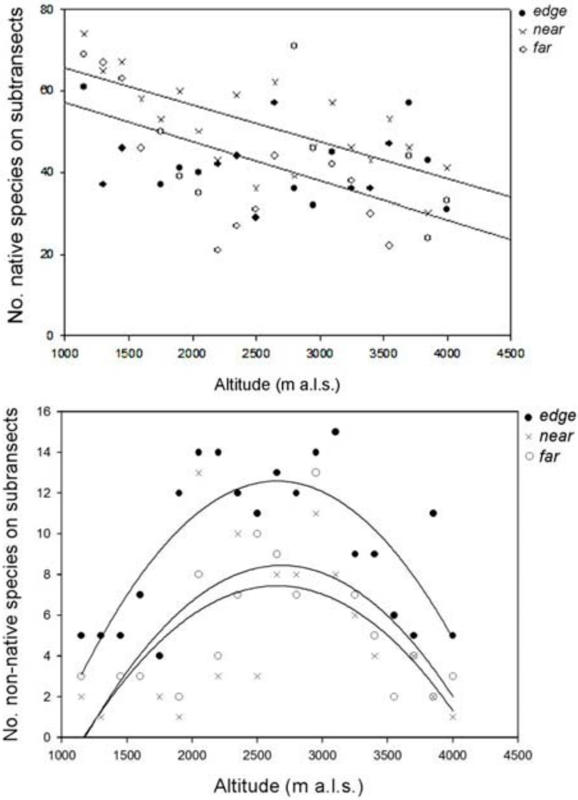

Figure 1. Distribution patterns of non-native and native species along altitudinal gradient in Eastern Cordillera of Ecuador, considering distance of road (*edge*: higher disturbance, *far*: lower disturbance). Native species always showed a monotonic linear decrease with elevation (except on *edge*), while non-native species always showed a quadratic relationship.

Synergistic effects of soil characteristics, allelopathy, and frugivory on the establishment of the invasive plant *Carpobrotus edulis*

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Coastal dunes are very dynamic and highly fragile ecosystems that are constantly evolving and changing. Adverse environmental conditions, such as the presence of salt spray, substrate mobility, high winds or low water availability, cause a marked selection and specialization in coastal dune plants. Therefore, these ecosystems have a high cultural and ecological interest, and support many threatened and endemic species (Council Directive 92/43EEC). In the establishment of native plant communities, seed germination is a very important element that determines their structure and functioning (Matilla 2003). One of the major invaders of these ecosystems in Spain is a South African succulent species, *Carpobrotus edulis* (L.) N.E.Br. is an exotic species from South Africa. Since the interactions between invasive and native species at the germination stage of population development can principally affect the invasion success of *Carpobrotus*, we studied experimentally its competitive relationships with a co-occurring annual native species *Malcolmia littorea* (L.) R.Br. Our approach results from the following premises: (i) *Carpobrotus* changes the quality of invaded microsites, exerting a great impact on community composition, diversity and succession (Donath and Eckstein 2010). Some of these changes (moisture content, pH, and salinity) influence the establishment of native plants (Novoa and González, unpublished). (ii) In addition, there could be an allelopathic effect of *Carpobrotus* on *Malcolmia*. (iii) Efforts to eradicate *Carpobrotus* and restore dunes, promoted by some Spanish Regional Governments and the Portuguese Government, have failed, because three years after the campaign the restored areas are reinvaded by *Carpobrotus* growing from seeds. (iv) *Carpobrotus* produces fleshly indehiscent fruit in early spring, which is not released from the plant until autumn when it is eaten by a variety of native mammals. Rats and rabbits are the primary seed dispersers of *Carpobrotus* species (Bourgeois *et al*. 2005). The dispersal of *Carpobrotus* by a variety of unspecialized consumers likely contributes to its success as an invader (D'Antonio 1990). Uneaten fruits remain attached on the plants for several years. Our hypothesis was that there is a synergic effect between the above factors, facilitating germination and dispersal of *Carpobrotus* at the expense of native plants, and favouring the invasive species in competition. To obtain insights into the assumed mechanism, we tested the effects of pH, moisture, salinity and allelopathy, and their interactions, using *Carpobrotus* litter of different ages (1, 1.5 and 3 years), on (i) the germination of its seed collected directly from fruits and of seed that went through mammals' intestines, and (ii) on competition between the seed of *Carpobrotus* and *Malcolmia littorea*. The implications of the obtained results for the maintenance of native plant diversity and restoration of dunes are discussed.

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How understanding ecological interactions provides tools for conservation biocontrol of the weedy leafy spurge (*Euphorbia esula*)

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Leafy spurge (*Euphorbia esula* L. subsp. *esula*, Euphorbiaceae) is a well known invasive species, not only in North America but also in Europe, its native range. Since the 1990s, its invasiveness has been reported in the floodplains of Val de Saône in central-eastern France, which are considered the last and largest European flood-meadows. Growing in dense patches, this latex-rich plant is toxic to cattle when present in cut hay. Annually mowed grasslands are losing their profitability as soon as they are infested. This economic loss may lead to ecological issues such as the shifting of mowed pastures into intensive agriculture (corn) and forestry (poplar). Natural annual floods and various agricultural practices such as mowing and grazing promote a rich floral and faunal diversity, which is protected under the Natura 2000 network. Our project is an original multidisciplinary approach to the study of invasive plant/natural regulator/agricultural practice/biotic factor interactions in two ways: 1) we are determining the biological, genetic, ecological, and agricultural factors triggering leafy spurge invasiveness, and how these factors interact; and 2) we are proposing an integrated biocontrol program combining previously obtained data, by targeting invasive plant/natural regulators interactions, connected with agricultural practices, based upon field and laboratory tests. Preliminary field results (Figure 1) show that, as suspected, all factors tested are influencing the plant/insect complex. Mowing has a major impact on shoot density (shoots/m^2), increasing it by two times on average. Mowing also negatively impacts the population size of the insect *Oberea erythrocephala* (Cerambycidae) by suppressing older shoots. This beetle is one of the natural phytophagous regulators of leafy spurge, and aged shoots are its major oviposition substrate. Grazing, including trampling caused by this practice, has an opposite effect, mainly on non-mowed patches that appear to attract cows. Shoot density decreased by 50 to 95% in August. This practice occurs only after *O. erythrocephala* population and oviposition peaks, reducing the potential impact on the density of its population. The flood factor does not seem to impair plant health. Further studies may show a positive impact on the increase of shoot density.

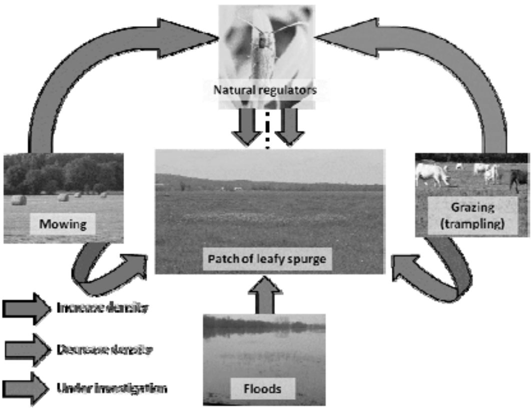

Figure 1. Action of the different environmental and anthropic factors on leafy spurge shoots density and its associated natural regulators.

Native herbs early response to grazing abandonment in NW Patagonia

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In the mid twentieth century, vast areas of southern beech (Nothofagus) forests were burnt for conversion into grasslands for livestock production in western Patagonia, Chile (Veblen *et al*. 1996). Grazing by cattle is common practice in both grasslands and native forests fragments, but consequences for biodiversity conservation are poorly known. In the resulting landscape mosaic, native herbaceous species coexist with non-native species introduced by settlers for forage production. Grazing abandonment is expected to favor native herbs and to be detrimental to non-native species in both forests and grasslands. To test this hypothesis, we installed permanent exclosures in contact areas between native forests and grasslands where plant species composition and diversity was measured. One year after the cessation of grazing, we observed a decrease in species number of native herbs, but an increase in their abundance, especially in deforested grasslands, which suggests that native herbs represent two different grazing response groups. Former grazing by large wild herbivores, such as huemul and guanaco, could have favored the coexistence of both grazing-tolerant and grazing intolerant species among the native herbs. Conversely, the non-native species did not show that early response to grazing cessation. Forthcoming plant diversity measures would provide valuable insights for community dynamics and biodiversity conservation in these ecosystems.

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Old field succession in Mediterranean grasslands of Central Chile: the role of alien species

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In the Mediterranean region of Chile over 25% of their plant species are exotics, most of which came from the Mediterranean Basin. Spanish agricultural practices were exported to Chile, and most of the invasive species are associated with this cultural scenario. This process of species naturalisation is more important in the agrosilvopastoral system known as *Espinal*. However, only 15% of the herbaceous species from the centre of the Iberian Peninsula are naturalised in central Chile, so the study of the selection process of arriving and establishment of alien species in central Chile implies difficulties and it is not very well known yet. In this context, crop fields, particularly along their succession stages following abandonment, constitute the communities showing the highest values for richness and number of alien plants in Chile. In the present study, we focused on this successional process, in order to know how Chilean Mediterranean communities of herbaceous plants (native and alien species) change in the course of time. We selected four sites in Chile according to their management, which should include areas covering a broad temporal gradient of land abandonment after crops cultivation. In each site we considered four different successional stages: i) first year after crop cultivation, ii) between one and three years of abandonment; iii) from fourth to tenth years, and finally, iv) mature communities, abandoned more than forty years ago. In each successional stage of each site we recorded species richness, number of native and alien species, and number of annual and perennial plants. Our main objective was to characterize the variation of these variables along the temporal gradient associated with succession process. Firstly, species richness significantly increases in the course of time. Alien species are dominant in pioneer successional stages, and they do not have a significant increase along time. On the contrary, the presence of native Chilean herbaceous species at the pioneer successional stage is very low, but they significantly increase along the secondary successional gradient. Although their presence becomes more important with time, there is not a displacement of alien species. Finally, associated with the successional process, there is an increase of perennial species, most of which are natives. These results suggest a final scenario composed by mature grassland with high biodiversity, where native species coexist with exotic ones in the same community.

The rich get richer: socioeconomic status, taxonomic and functional composition in urban green areas of Valdivia, Chile

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Human made habitat modify natural environments and affect natural processes. Cities are an extreme transformation of the landscape in which natural drivers of community assembly interact with anthropogenic drivers, generating new selection pressures that lead to new ecosystems. Species gain (by introduction or colonization) and loss happens intentionally and/or unintentionally, changing biodiversity and species interactions (Williams *et al*. 2009). Previous studies have shown a relationship between socioeconomic factors and species richness and describe the functional composition of urban areas (Knapp *et al*. 2012). The knowledge of how these changes, however, may affect ecosystem functioning is still not clear and can be assessed by analyzing functional traits more thoroughly.

In this study we aim to assess environmental and human filters (soil and socioeconomic factors, respectively) as drivers of taxonomic and functional composition of the spontaneous vascular flora of urban green spaces. Thus, we sampled habitats in urban public green areas of residential sectors in the city of Valdivia, Chile, as a case study. We selected our plots randomly, stratified by the socioeconomic classification of the governmental National Institute for Statistics of Chile (INE). Ten plots were sampled in lawn like areas of Squares and broad sidewalks green areas per each of the four socioeconomic level used. All spontaneous vascular plants and their abundance were measured. We recorded plant height, leaf area and leaf weight, leaf dry matter content (LDMC) and specific leaf area(SLA) as leaf traits, following LEDA standards, for all the plants except the rare ones (≤ 3 individuals per plot). Preliminary results suggest that the urban plant communities in Valdivia are dominated by European plants, showing a tendency of homogenization due to the higher proportion of aliens. Higher income areas had significantly higher species richness and SLA (i.e., plants with short-lived and easily degradable leaves) and specifically, broad sidewalks habitats have significantly higher LDMC (i.e., plant species with tough leaves adapted to resist disturbances like occasional trampling). Future research in urban areas of Latin-America may contribute to the understanding of the functioning of novel ecosystems, what will help to predict future changes that we will confront with global change.

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Fire promotes downy brome (*Bromus tectorum* L.) seed dispersal

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Particularly well-known among the many impacts of the invasive annual grass downy brome (*Bromus tectorum*, Poaceae) is its ability to alter fire cycles and increase in abundance after fire. However, little is known about how fire influences *B. tectorum* dispersal. We quantified fire effects on *B. tectorum* dispersal using three recently burned areas in the western region of the Colorado Rocky Mountains by marking diaspores (seeds) with fluorescent powder, and then recovering them at night using ultraviolet lights. Diaspores were of two types: with and without sterile florets attached. We also characterized vegetation cover and near-surface wind speed in burned and unburned areas. Diaspores travelled much further in burned areas than in nearby unburned areas (means ± standard error at the end of the experiment: 209 ± 16 cm and 38 ± 1 cm, respectively), indicating an increase in dispersal distance after fire. Diaspores with sterile florets attached dispersed longer distances than those without sterile florets (means ± standard error at the end of the experiment: 141 ± 14 cm and 88 ± 7 cm, respectively). Vegetation cover was lower and wind speeds were higher in the burned areas. Our results indicate that at least one of the mechanisms by which the spread of *B. tectorum* is promoted by fire is through increased seed dispersal distance. Preventing movement of seeds from nearby infestations into burned areas may help avoid the rapid population expansion often observed.

Low persistence of a monocarpic invasive plant in historical sites biases our perception of its invasion dynamics

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The persistence of species at sites once colonized affects their distribution in the landscape. Since precise actual distribution of the species is rarely available our knowledge usually relies on cumulative records, while the issue of persistence is largely neglected. This issue is highly relevant in changing modern landscapes, especially for dynamic invasive species and unstable human-made habitats. This is even more pronounced in the case of alien species where most attention is paid to the spread and colonization.
In this study (Pergl *et al*. 2012), we explored the persistence of a monocarpic invasive species, *Heracleum mantegazzianum*. Of the total number of 521 historical sites, in which the species occurred between the end of the 19th century and present, it persists in 23.8% of sites. The persistence rate differed with respect to individual habitat types and the results indicate that factors that best explain the persistence are: type of habitat; urbanity; proximity to the place of the species' introduction into the country; metapopulation connectivity; and distance to the nearest neighboring population.
The results show that using cumulative historical records as a measure of species distribution, as is often used in invasion literature, can yield seriously biased results that overestimate both the actual distribution and the rate of spread. Therefore, in the case of highly-fugitive alien species with low persistence, estimates of distribution and the rates of spread based on cumulative historical data reveal more about the distribution of habitats potentially suitable for colonization than providing an accurate picture of their real occurrence.

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Demographic responses of a invasive plant across altitudinal gradients: the case of *Eschscholzia californica* (papaveraceae) in central Chile

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The invasion of alien species is basically a demographic process. During this process, the invaders colonize and establish in a context of environmental heterogeneity. Altitudinal gradients constitute appropriate scenarios to analyze invasive processes and have regarded significant barriers to plant invasion (Becker *et al*. 2005). To understand the demography of invasive species across altitudinal gradients is critical to elucidate constraints (or not) to invasion to higher altitudes. *Eschscholzia californica* (Papaveraceae) is a perennial herb original from California (USA) and a successful invader across Mediterranean ecosystems. In Chile, the first register of this species goes back to 1890. Since that date, it has spread across central Chile, ranging from 0 to 2200 masl and from 30° to 30° latitude. During 2009 y 2010, we visited 5 populations of E*schscholzia californica* in Central Chile across an altitudinal gradient, ranging from 0 to 2200 masl. From field data, we could estimate for each population (i) seed probability to survive and growth to adult stage (R) (ii) adult fecundity (F_A); (iii) seed probability to survive and remain as seed stage (P_s) and adult probability to remain as adult stage (P_A). Then, we constructed a two- stage matrix for each population, and estimated the finite rate of increase ג ; we also conducted LTRE (Caswell 2001) comparing ג differences between low vs. high altitude populations. ג varied significantly across altitude, being higher (ג > 1) at coastal populations and lower at mountain populations (ג = 1) (Figure 1). On the other hand, LTRE indicated that P_s contributed more significantly to ג differences between coast and mountain populations. Our results suggest that this species has the potential to spread at lower altitude, in opposition to the populations of higher altitude which expressed a demographic equilibrium at higher altitudes. Moreover, seed stage seems to be more sensitive than adult stage to biotic/abiotic constraints that occur at higher altitudes. We conclude that, this species has stopped invasive process to higher altitudes.

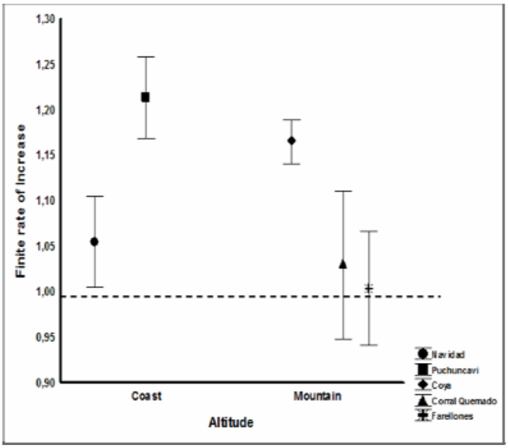

Figure 1. Finite rate of increase (λ) estimated for different populations of *Eschcholzia californica* located at the coast and mountains, Spring 2009 and 2010, Central Chile. Values represent averages ± 1.96 standard error. Dotted line represent λ = 1

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Ecological requirements, short-term dynamics and competition among native and invasive Impatiens species: a field test

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Comparison of invasive, naturalised non-invasive and native plants can provides useful insights into factors conferring invasiveness if carried out on congeners because such approach eliminates phylogenetic biases. We studied ecological requirements, short-term dynamics and competition of native and invasive species of the *Impatiens* genus (Balsaminaceae), widespread in the Czech Republic, in two field experiments. *Impatiens noli-tangere* is native in the study region, *I. glandulifera* and *I. parviflora* were introduced from Asia; the former species spread rapidly in Central Europe especially in the last 50 years, while the rate of spread of the latter has been lower recently. We established two sets of permanent plots in five localities hosting all the three species. In the first set, site characteristics such as tree canopy cover and soil humidity were directly measured, and nutrients, light, humidity and soil reaction estimated using Ellenberg indicator values. Although the species often occur in the same locality, there were signs of micro-site differentiation. The results show that the presence of *I. noli-tangere* is strongly correlated with high soil moisture, that of *I. parviflora* with low soil moisture and high tree canopy cover, and *I. glandulifera* with high carbon and nitrogen content. These results indicate possible but limited coexistence of the three species in the field. Directly measured characteristics were better predictors of the *Impatiens* species presence than variables based on Ellenberg indicator values that provide only a rough estimate of environmental conditions. Surprisingly, the short-term dynamics of the species studied were not influenced by their abundance in the site in the previous year. The current-year abundances were negatively related to the abundance of congeneric species and soil moisture. In the second experiment, one species of the native-invasive congeneric pair was removed and the intact plots used as controls. In all treatments, the abundance and cover of the target species increased following the congener's removal. The greatest increase in the number of plants was found for *I. noli-tangere* in response to the removal of *I. parviflora*, and the smallest in *I. parviflora* in response to that of *I. noli-tangere.* The greatest increase in cover was recorded for *I. noli-tangere* in response to the removal of *I. glandulifera* and the smallest in *I. noli-tangere* in response to the removal of *I. parviflora*. The results point to rather poor completive abilities of the native *I. noli-tangere* and its different response to the invasive congeners.

Lantana camara L.: a weed with a wide thermal tolerance at darkness

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Low and high temperatures are known as one of the most important factors influencing plant performance and distribution. Plants of *Lantana camara* L. coming from two distinct geographical populations (Iberian Peninsula and Galápagos Islands) were cultivated in a common garden experiment and their leaves were subjected to thermal treatments from +20.0 ºC to -7.5 ºC during the winter and from +20.0 ºC to +50.0 ºC during summer, in a programmable water bath at darkness. Their photosynthetic performance and their recovery capacity after the thermal treatment were evaluated by measuring chlorophyll fluorescence, net photosynthesis rate and leaf necrosis. In general, *L. camara*'s photosynthetic apparatus showed a wide range of temperature tolerance at darkness, showing optimal functioning of its PSII (F_v/F_m between ca 0.750 and ca. 0.870) just after exposure to temperatures between -2.5 ºC to +35.0 ºC for the Iberian population and between +10.0 ºC to +25 ºC for the Galápagos population. Just after exposure to low and high temperatures, gradual cold and heat–induced photoinhibition respectively were recorded for both populations, due to the decrease of F_m and constant values of F_0 at low temperatures, and on the other hand due to the decrease of F_m and the increase of F_0 at high temperatures. After 24 h, leaves of *L. camara* demonstrated a great recovery capacity, by showing F_v/F_m values close to 0.8 and P_N values between 10-16 µmol O_2/(m^2 s), from -2.5ºC to +45.0ºC. However, leaves of the treatments from -5 ºC down and +47.50 ºC onwards, showed low values of F_v/F_m and together with low P_N values and necrosis, denoted permanent damages to the photosynthetic apparatus and to the leaves tissues. Slight interpopulation differences were found only at extreme temperatures.

Key biological indicators to assess Invasive Terrestrial Plant Species in the Măcin Mountains National Park. Romania

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Măcin Mountains National Park is located in the northern part of Dobrogea (Tulcea County) at the crossroads of biogeographical regions hosting unique flora and fauna, with numerous protected species having their northern or western limit here. It is the only national park (II IUCN category) sheltering old Hercynian Mountains and a combination of Pontic, steppe and well-preserved Submediterranean and Balkan forest ecosystems.
The paper is aiming to identify and analyses the key biological indicators able to reveal the occurrence, development and spread of the main Invasive Terrestrial Plant Specie (ITPS) in the Măcin Mountains National Park with a special focus on *Ailanthus altissima* (the heaven), considered as one of the most dangerous invasive tree species in Europe because it penetrates into natural vegetation and irreversibly changes its composition.
In the study-area, the heaven mainly affects the steppe and sylvo-steppe dry grasslands, forest skirts, riparian habitats etc. by competing and removing the native local species. The control of this specie is quite difficult because the mechanical eradication methods (cutting, hand pulling etc.) are not always efficient, therefore they must be completed with other mechanical and even chemical methods.
Based on several field surveys and the scientific cross-references, the authors were able to relate significant biological indicators (abundance, frequency, ecological significance etc.) with relevant key natural (climate, hydrology, soil, geomorphology, habitats etc.) and human-induced (transport network, build-up areas, waste deposits mining etc.) driving forces.
Assessing biological invasions in Macin Mountains National Park is of increasing importance due to their potential impact on indigenous flora and specific habitats and the ecological significance of this protected area.

Assessing the invasion risk of human-managed riparian forest by comparing seedling performance of co-occurring native and exotic tree species through an experimental gradient of light and soil moisture

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In continental Mediterranean Iberian Peninsula, the exotic tree species *Ailanthus altissima*, *Robinia pseudoacacia*, *Acer negundo* and *Elaeagnus angustifolia* are spreading throughout riparian forests, where they co-occur with the natives *Fraxinus angustifolia*, *Ulmus minor* and *Populus alba*. In these floodplains, human management of rivers has decreased the natural flood-consequent forest gap production and has increased the depth of the permanent water table, reducing water availability on surface. Furthermore, human disturbance is opening new permanent gaps in riparian forest. These actions have decoupled the combination of high water and high light availabilities in these forests where the native species regenerate and are creating new regeneration niches which may trigger invasion success.

Our aim was to asses the potential native/exotic outcome in both the non-human-mediated natural niches (high light-high water) and the new human-favored tree regeneration niches (low light-low water; high light-low water), in order to predict shifts in species dominance. To get our aim, we compared the biomass reached by seedlings of the mentioned native and exotic tree species after two growing seasons (2008-2009) under two experimental levels of light (100 and 7% of full irradiance) factorially combined with two levels of soil moisture (High and low moisture, 61 and 40% of soil gravimetric water content respectively).

In the non-human-mediated natural niches (high light-high moisture), all species showed similar high performances but the exotics *Elaeagnus angustifolia* and *Ailanthus altissima*, which showed the highest and the lowest biomass, respectively. In contrast, a decrease in light and water availabilities through regulated river foodplains would limit the potential regeneration of most of the species but the exotic *Acer negundo* and the native *Ulmus minor*. Moreover, the human induced gaps with an increased water table depth would be a potential niche for all species but, in a lesser extent, for the exotics *Acer negundo* and *Ailanthus altissima*. Our results regarding *Ailanthus altissima* growth contrast with previous studies that considered this species an aggressive invader. We believe that the low biomass reached by this species was a consequence of the blizzard fell in January 2009, which could have negatively affected the non-frost resistant seedlings of *Ailanthus altissima.*

Our results suggest that the combination of invasive species with human-mediated scenarios will provoke shifts in species dominance and draw attention to the necessity of studying the resource conditions underlying these changes.

Assessing invasive terrestrial plan species *Amorpha fruticosa* in three wetland areas in Romania: Danube Delta Biosphere Reserve, Comana Natural Park and Lower Mureş Floodplain Natural Park

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Floodplain areas host unique ecosystems displaying exceptional habitats with high biodiversity hosting different species of fauna and flora. Under the recent human-induced influences and the occurrence of extreme climate phenomena, these vulnerable ecosystems become highly exposed to a wide range of environmental threats. Therefore, one of the leading pressures on habitats and biodiversity is related to biological invasions, wetland ecosystems proving to be among the most vulnerable environments to Invasive Terrestrial Plant Species (ITPS). One of the most aggressive ITPS in wetland areas is *Amorpha fruticosa* (the desert false indigo or the indigo bush) ranging first in terms of impact on local habitats and flora. In Romania, this invasive plant species is adapted to all types of environments, but it regularly prefers wetland habitats.

The authors are willing to put forward a comparative approach of this ITPS in three major protected areas in Romania (both Natura 2000 and Ramsar sites): Danube Delta Biosphere Reserve, Comana Natural Park and Mures Flood Plain Natural Park. The paper will focus on assessing species *habitat requirements, key environmental driving forces* (both natural and human-induced) and *relevant biological indicators* (abundance, frequency and ecological significance) in order to point out *Amorpha fruiticosa* particular features and potential distribution and spread.

Early responses of *Baccharis halimifolia* seedlings to salt stress: maternal environment matters

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The invasive success of exotic plant species may depend on the ability to deal with biotic and abiotic stresses encountered in the native community. Although threshold levels of stress can prevent the invasion through massive mortality, at moderate stress regimes, individual differences in physiological tolerance can have critical consequences at population level.
Baccharis halimifolia (Asteraceae) is a shrub native to North America and an aggressive invader of coastal habitats in Southern Europe (Campos *et al*. 2004). It colonizes sea rush communities with edaphic salinity levels going from 1 to 30 gNaCl/L, which evidences significant plasticity. However, the fitness of *B. halimifolia* decreases as salinity increases (Caño *et al*. 2010).
In these heterogeneous stress patches, population persistence and growth can be achieved through genetically based phenotypic plasticity. However, maternal environment salinity can also pre-condition offspring responses to salt stress (Van Zandt & Mopper 2004) and have important consequences for invasion success (*cf*. Dyer *et al*. 2010). Here we look for maternal environmental effects in early plasticity to salinity in *B. halimifolia* through a salinity gradient (0-20g NaCl/L) in controlled conditions. We grew plants from eight maternal lines collected in two different environments (low salinity *vs* high salinity) across a heterogeneous patchy population in Urdaibai Biosphere Reserve (Spain). We periodically measured growth and physiological traits during a 5-month growth experiment.
Growth of *B. halimifolia* seedlings decreased with increasing salinity and all maternal lines achieved limited growth at 20g NaCl/L. However, at lower and intermediate treatment salinity levels maternal lines from high salinity sites maintained higher total biomass than maternal lines from low salinity sites (Figure 1a).

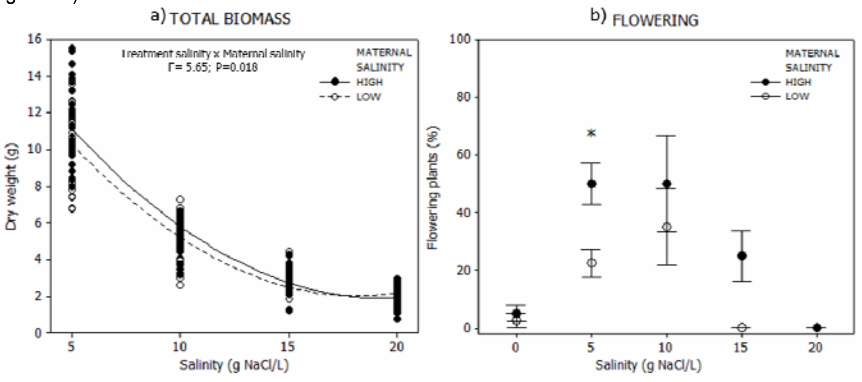

Figure 1. (a) Growth plastic response of *Baccharis halimifolia* seedlings after 75 days of growth in a salinity gradient. Observed values (dots) and model adjustment (lines) are represented. A GML model was used to assess the effect of the treatment (continuous variable), the maternal salinity (fixed factor), the maternal line (random factor) and the interactions. (b) Proportion of flowering plants of *B. halimifolia* maternal lines from low and high salinity maternal environments across a salinity gradient. Values are means (±standar errors). Significant differences within salinity treatments are indicated according to ANOVA.

Uniquely plants under intermediate levels of salinity started flowering before the end of the experiment, suggesting that salinity stimulates flowering. Interestingly, the proportion of flowering plants was higher in the offspring of maternal plants from high salinity maternal environment.

Leaf production increased through time in the control and the low salinity treatments but plants started losing leaves after 40 days under high salinity treatment (15-20 g NaCl/L). The offspring of high salinity maternal environment maintained lower and more stable amount of leaves through time than the offspring of low salinity maternal environment. Reducing the number of leaves at high salinity treatments was adaptive since the number of leaves was negatively correlated with probability of flowering.

Maternal lines from high salinity sites also showed more stable levels of water use efficiency through time. Moreover, after 45 days of treatment, the plastic physiological response to salinity differed between the maternal lines from high salinity sites and those from low salinity sites. While the formers showed lower photosynthetic rate and higher water use efficiency than the latters in the control treatment, this pattern tends to be reversed as salinity increased. Our results suggest that the increased fitness observed for maternal lines from high salinity sites might be achieved through homeostatic physiological responses and adaptive plasticity.

We conclude that maternal environmental effects and trans-generational plasticity may play a significant role in plant performance and invasion under stressful conditions.

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Dynamics of species composition of riparian vegetation *vs* spatial distribution of invasive *Fallopia* taxa

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One of the most invasive vascular plants in Poland are the representatives of the *Fallopia* genus, which penetrated both the plant communities transformed by human, and natural communities, including the alluvial plains. The riparian forest communities are especially valuable because of the extremely high species richness. The occurrence of invasive species in the forest type should be carefully monitored in order to determine the mechanisms of this process and develop effective methods to reduce and prevent this phenomenon. Differences in biology of the studied *Fallopia* taxa may result in differences in the way how they affect the riparian vegetation patches in which they occur.

The aim of this study is to determine whether there are differences in species richness, diversity indexes and the structure of functional groups (e.g. participation of life forms, participation of native and alien species and participation of species representing different life strategies) between patches of riparian forest dominated respectively by *F. japonica*, *F. sachlinensis* and *F*. x *bohemica*.

For this purpose data were collected from riparian forests located along two river valleys in the south of Poland. Data about species composition, species cover and abiotic side conditions of the studied vegetation (inside the established permanent plots) were recorded.

The preliminary results were focused on recording the relationships between the participation of the particular *Fallopia* taxa plants and values of diversity indexes. The results revealed significant negative correlation between the *Fallopia* taxa cover and the value of the Shannon-Wiener (*H'*) index as well as the species richness (S). There was no such results for the Simpson index and Evenness. Canonical Correspondence Analysis (CCA) performed for the matrix containing the abiotic habitat data for the permanent plots area showed that at the beginning of growing season the available magnesium, pH and N (nitrate, ammonium) influence the species composition of the patches studied. Vegetation patches dominated by *F. japonica* were more closely related to the higher pH values, while patches dominated by *F*. × *bohemica* were more often recorded on sites richer in available potassium and magnesium. Vegetation patches dominated by *F. sachalinsis*were characterised by higher proportion of nitrogen compounds in the soil. The analyses show similarities in chemical characteristics of habitat parameters for *F. japonica* and *F*. x *bohemica.*

Spontaneous associated plants in short rotation coppice: challenge for invaders

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The world is currently looking for new and renewable energy resources. One of the solutions is to exploit the energy accumulated in biomass. New plantations of energy trees are established world-wide without knowing the species composition of the associated vegetation that penetrates in these plantations.

Our research has been focused on monitoring of biodiversity in *Salix* stands (locality: Experimental Centre of the Slovak University of Agriculture, Kolinany, Nitra District, Slovakia). During our observations in a four years period, the dominant species in the herb-layer of energy trees were shadow tolerant weeds known from the surrounding fields of common agricultural crops (cereals, maize, rape grain etc.). The phytocoenoses were dominated by apophytes (*Equisetum* spp.*, Symphytum officinale, Urtica dioica* etc.), archeophytes (*Capsella bursa-pastoris, Cardaria draba, Echinoichloa crus-galli, Fallopia convolvulus, Lactuca serriola, Lathyrus tuberosus, Tripleurospermum perforatum* etc.) or by a group of species where it is not possible to decide whether they are native apophytes or archeophytes (*Artemisia vulgaris, Chenopodium album, Convolvulus arvensis, Stellaria media, Tanacetum vulgare* etc.). The three most common neophytes with high invasive potential were *Conyza canadensis, Stenactis annua* and *Aster novi-belgii* agg. The South American originated ruderal neophyte *Galinsoga parviflora* was evaluated as a casual and in the case of *Amaranthus retroflexus* it is not clear whether it is an archeophyte or neophyte. Invasive neophytes occurred usually in the margins of the short rotation coppice (edge effect) and formed generative propagules for further dispersion. The spontaneous vegetation of herb aspects consisted of species with different environmental needs (different optimum of light intensity, nutrients, water, soil type etc.) but tolerating a wide range of conditions at their pessimum. The main limiting factor was the light in the shade of canopy closure of *Salix* trees mainly in the second half of the vegetation period (the individual herbs were of a taller growth and also later or no blooming was observed). The syn-phenological optimum of weed aspects was in early spring. Both the year-long life-cycle and the long-term ecological succession have been shifted from the field annuals (pioneers with r strategy) towards shade-tolerant perennials (non-clonal K strategists). The typical herb-layer species of (willow-dominated) floodplain forests were absent.

In *Salix* plantations, also seedlings of spontaneous woody species occurred (from the genera *Crataegus, Swida, Prunus, Cerasus, Acer, Quercus!*, *Sambucus* etc.), but no invasive trees have been found.

No significant influence of identified invasive species on the growth of energy willow trees was observed.

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A transcontinental biogeographic comparison of native and invasive dominants: Are invasives indeed doing something different than natives?

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Despite ongoing intensive research on exotic plant invasion, we still have a rather poor understanding of whether the same species has different impacts in its native and invasive ranges. Some species that are rare in their native range may suddenly reach staggeringly high population densities and become dominant when they are introduced into a new range. In contrast, other species are capable of being dominant in both ranges. This implies that the fundamental difference might be in how resident communities in both ranges respond to their dominants and what their resilience is following disturbance. The present study aims to test this assumption by using a biogeographic comparison of three model (semi)grassland species (*Cirsium arvense*, *Leucanthemum vulgare* s. l., and *Tanacetum vulgare*) native to Europe and invasive in North America. In both ranges, we have established eighteen experimental sites in which the given species is either a native dominant or an alien dominant to explore how the plant community responds (in terms of plant species richness, diversity and composition) after a disturbance event. We designed each plot with a complete block of four randomized treatments: soil disturbance/no seed addition, soil disturbance/seed addition, no soil disturbance/no seed addition (control), and no soil disturbance/seed addition. Seed addition means that seed of six common native plant species growing at the experimental site were added to the plot to strengthen the natural level of propagule pressure from the surroundings.

Here, we report the preliminary results from the first year of the project. In general, the studied plant communities seem to be more species-rich in the native range compared to their new range. Concerning the species composition, North American sites contain many more aliens than their native counterparts. The first year after the disturbance, we observed an obvious difference between the seeded and unseeded plots in both ranges. Weedy species and r-strategists (annuals) have predominantly colonized disturbed plots in Europe, whereas alien species and r-strategists (annuals) were found within the plots in North America. The introduced species studied herein recover after disturbance better than their native counterparts in terms of abundance and cover. Moreover, the introduced species are significantly higher in the new range than at home that might facilitate them to compete for light.

Colonizer potential and invasion pattern of *Acacia dealbata* Link in Chile and Spain

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Plant invaders of native communities are considered as one of the greatest threats to the conservation of native ecosystems. Tree exotic species cause important changes in ecosystem processes, community structure and displace native species. However, invasion patterns may vary between regions, habitats and communities, even within the same region. Also, introduced species may provoke different responses in different plant communities. *Acacia dealbata* Link native to Australia and Tasmania was introduced to Chile and Spain as an ornamental plant and has been documented as invader in the Mediterranean zone of Chile (Bio Bio) and Spain (Galicia). In these areas *A. dealbata* exerts significant competitive pressure and constitutes serious threat to native vegetation. Different experiences were designed to know the potential of *A. dealbata* as invader in Chile and Spain. Experimental design comprises: i) field studies to determine whether the invasive ability of *A. dealbata* depending on natural conditions and ecosystem type. Three levels of invasion status were evaluated: invaded, transition (intermediate matrix) and non-invaded areas. Number of new individuals, growth (perimeter and height increment) of the invasive were monitored. Plant density, species richness, composition, survival curves of native plants was recorded. ii) greenhouse and laboratory experiments to check the allelopathic interference of the invasive *A. dealbata* on native plants. Germination, radicle and shoot lenghts, net CO_2 assimilation rate, net photosynthesis and respiration rates were assessed by natural rain leachates, macerates and soil extracts obtained from *A. dealbata* stands. *Acacia dealbata* can invade different undisturbed ecosystem types. The invasive ability of the exotic was more closely related to abiotic conditions, such as light availability, than species composition or diversity of threatened ecosystems. *A. dealbata* can spread by producing sprouts that act as new individuals in the new area, and by growing rapidly (depending on the ecosystem studied) in spring and fall seasons. Despite tree invasions depend highly on disturbance regimes to be successful, in the absence of disturbance regimes, *A. dealbata* can successfully establish and grow in native areas of undisturbed ecosystems. However, native ecosystems such as closed-canopy oak forest slowed the spread of *A. dealbata*. On the other hand, native species perform poorly in invaded areas. The effects of *A. dealbata* extracts depended on extract type, phenological period of the exotic, physiological parameter of native plants (germination, radical and shoot length, net CO_2 assimilation, net photosynthesis and respiration rates) and were species-specific. Radicle length of *A. dealbata* was particularly stimulated by their own extracts suggesting a role of positive autoallelopathy in the invasion process. Despite this, some native species has a higher survival rate than *A. dealbata* within the *Acacia* invaded stands demonstrating that other abiotic characteristics (light or water) can interact in the plant relationship. Apparently, the success of the *A. dealbata* to spread into non-invaded areas is not due to a single mechanism; it seems involve a set of interrelated processes.

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Unfaithful lovers. Are the invaders overly dependent on their new relationships?

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Plants and soil microorganisms have co-evolved to configure rhizosphere relationships as we describe it today. These associations (positive or negative) have a key role in the vital trade-off in which species are forced to invest in defense, growth or reproduction depending on their resources. In this context, when a species enter in a new habitat, the release of its natural enemies (enemy release hypothesis; Elton, 1958; Keane and Crowley, 2002) entails a better competitive ability (evolution of increased competitive ability hypothesis; Blossey and Notzold, 1995). Into the novel range, exotics avoid the presence of coevolved antagonisms (also mutualisms) and in some cases, traits, as the "symbiotic promiscuity" in legumes also increases their competitive ability due to the formation of novel associations (Rodríguez-Echeverría, 2011). With these premises we hypothesized that the invasive exotic *Acacia dealbata* Link (silver wattle) have more benefits because of its soil microbial associations in a novel ecosystem than native plant species. This Australian woody invader is the unique species within the *Acacia* genus considered as invasive in Spain (MARM, 2011).

To test this hypothesis, an experimental approach using sterilized vs non-sterilized soil from a local shrubland (NW of Spain) was carried out. In a greenhouse assay, the leguminous common gorse (*Ulex europaeus* L.) and scotch broom (*Cytisus scoparius* (L.) Link) and the grasses bristle bent (*Agrostis curtisii* L.) and orchard grass (*Dactylis glomerata* L.) together with the invasive *A. dealbata*, were independently grown in pots filled with sterilized (triple autoclaving on three successive days) and non-sterilized soil (replicates equal five). During the week 6, non destructive measurements were taken (height and number of leaves) and 12 weeks after the start of the assay, plant material was harvested and biometric measurements were taken (height, number of leaves, root length, shoot biomass, root biomass).

During the first measurement (data not shown) with the *A. curtisii* exception, height was generally diminished due to sterilization. After the harvest (Figure 1), *A. dealbata* was the most severely affected species with almost every measured parameter drastically reduced due to the soil sterilization. Nodules were absent in the sterilized pots for all the studied species but also in the non-sterilized pots for *Acacia* so, other factors instead of nodulation were probably responsible for the reduced growth showed in the invasive plant. In fact, *A. curtisii* and *D. glomerata* even were positive influenced due to sterilization, especially in the *A. curtisii* case whereas all the measured parameters in *U. europaeus* remained unchanged despite of the significant descent in nodulation. The significant reduction in the parameters shown by *C. scoparius* seems to be related with the absence of nodules because of sterilization.

These results suggest that the early growth of the invasive species, *A. dealbata,* is possibly more dependent of the soil microbial community than native species. The growth strategy for the native legumes *C. scoparius* and *U. europaeus* is different; the former seems to be dependent on nodules and *U. europaeus* do not modify its early growth in function of the soil microflora.

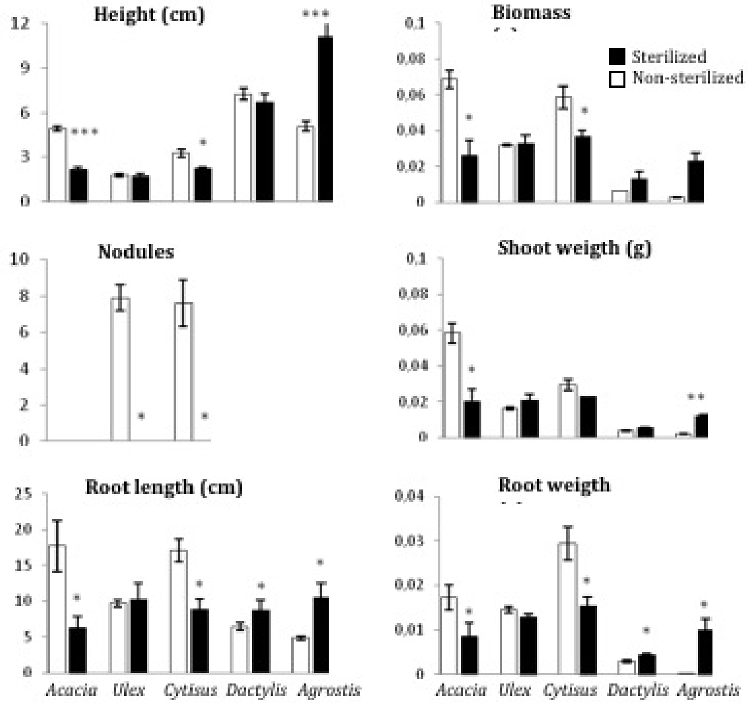

Figure 1. Mean (± SE) of the different biometrical measurements at harvest (12 weeks) between sterilized and non-sterilized soils for the selected species. Asterisks represent statistical significance: * $p<0.05$; ** $p<0.005$; *** $p<0.001$. *Acacia=A. dealbata; Ulex=U.europaeus; Cytisus=C.scoparius; Dactylis=D.glomerata; Agrostis=A.curtisii*

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What controls the distribution of three invasive trees in Spanish riversides

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Ailanthus altissima, *Robinia pseudoacacia* and *Ulmus pumila* are non-native tree species rather common in Spain, as they have been widely used as ornamentals. Nevertheless, their distribution has not been studied accurately in this country. The aim of this contribution is to identify their distribution and to establish which factors determine their presence in riparian environments in three different zones of Spain, contrasting in climate and human pressure. This will provide the basis for understanding their potential spread and prevent their future establishment.

From November 2010 to July 2011 we covered a band of c.a. 500 m wide on each side of three different rivers: the Henares River in central Spain, the Oria River to the north of Spain and a stretch of the low Ebro River in northeastern Spain. Patch features such as length, width, density of stems and origin (natural/planted) as well as abiotic factors including altitude, land-use, distance to railways, to roadsides, to urban cores and to the river were calculated for each patch. All information was processed in ArcGIS.

We identified 178 patches of *A. altissima*, 216 of *R. pseudoacacia* and 240 of *U. pumila*. In the Oria riverside we only found *R. pseudoacacia*, whereas the three species were present in the other two areas. Almost half of the patches of the three species were located within 100 m from the river in the three areas (45% for *A. altissima*; 48% for *R. pseudoacacia*; 38% for *U. pumila*). All species were found near roads and paths but far from highways. Patch size range was broad; remarkably, they consisted of one single individual in most patches of *U. pumila*. While *A. altissima* formed the thickest stands (less than 2 m among individuals), individuals were separated by 2-5m in the case of *R. pseudoacacia* and there was no clear pattern for *U. pumila.* The majority of the patches for all the species were planted in central Spain (most of them having naturalized). In contrast, non-planted patches predominate in the other two areas.

Our results suggest that urban areas and roadsides have contributed to the spread of these exotic trees, which are subsequently able to jump to riversides. Therefore action should be taken to control and avoid alien species expansion to better preserve riparian forests in Spain.

Plant-soil feedback and invasion by Australian acacias

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Cumulating studies have demonstrated that plant-soil feedbacks can have important ecological effects. While positive plant-soil feedback may promote species dominance, negative plant-soil feedbacks are thought to promote plant community diversity and favour the progression of succession (Bever, Westover, & Antonovics, 1997). In the particular case of plant invasions, special attention relies on soil biota's influence on plants (Levine *et al*. 2006). An important role may be played by soil microbial communities in the context of plant invasions, once invasive species may interact with soil microbes in the introduced range in a significantly different manner comparing to the way natives do (Wolfe & Klironomos 2005).

The objective of this study was to analyse the role of soil on the progress of invasion by two Australian acacias considered invasive in Portugal, *Acacia dealbata* Link and *Acacia melanoxylon* R.Br., by assessing: a) existence of biotic resistance of native communities; b) existence of self-facilitation of the invader through positive plant-soil feedbacks; and c) the role of disturbance (wildfire) on the effect that soil can have on acacia growth.

The two species were examined for plant-soil feedbacks in parallel greenhouse experiments. Feedback was evaluated by examining biomass variation in plants grown in unsterilized and sterilized soils from native, disturbed and invaded areas of two different sites (Gerês Mountain, in North Portugal, and Lousã Mountain Range, in Central Portugal). Both biotic (arbuscular mycorrhizal root colonization and nodulation by rhizobia) and abiotic soil characteristics (pH, nutrients) were considered in this study.

The working hypotheses were: 1) soil biota and chemistry will be different in native, invaded and disturbed soils; 2) *Acacia* growth will be greater in the invaded soil than in native soil (plant-soil positive feedback); 3) acacias will grow more in soils from disturbed areas than in native soils; 4) soil sterilization will have a negative effect on acacia growth due to the absence of mutualistic microorganisms.

Our results generally support some of the initial hypotheses: both plant species seem to beneficiate from disturbance by fire at one site; both species are negatively affected by soil from vegetation dominated by *Pinus pinaster* Aiton; both species growth in invaded soils was not significantly different from growth on soils dominated by native vegetation (*Quercus* sp., etc.), with the exception of A*cacia melanoxylon* growth at one site; both species generally benefit from soil mutualists, mainly from invaded soils and soils disturbed by fire.

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The extended flowering period of the invasive *Acacia longifolia* under mesic conditions can enhance the invasive success

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Reproductive traits are an important component of establishment and spread of non-native plant species and then in their invasiveness character. In Portuguese dune ecosystems, *Acacia longifolia* is one of the most aggressive invasive plant species and can be present in habitats ranging from mesic to xeric conditions. In this study we aim to evaluate the changes in the phenological behaviour and reproductive output of *A. longifolia* imposed by different climatic conditions: mesic and xeric conditions. The study was conducted at two different sites on the Atlantic coast of Portugal, located at northern (Osso da Baleia) and at southern (Pinheiro da Cruz), 180 Km north and 70 Km south of Lisbon, respectively. In the northern site annual precipitation is higher with lower air temperature and a shorter drought period than in the southern site. In each site we have studied *A. longifolia* trees under pine forest canopy and in an open sand dune area. Additionally to climatic variation, forest characteristics such as density and canopy cover are higher in the northern than in the southern. Along a time period of 2-years (2010-2011), a monitoring study was undertaken to compare the timing of phenological phases, the number of inflorescences and fruits production, the inflorescences/fruits ratio and the % of fruits aborted, at both study areas. The results showed that all considered phenological phases started and ended earlier under xeric conditions than under more mesic ones. In particularly, we observed a significant difference in the flowering timing as well as in the flowering phase duration, with longer flowering period under mesic climate. The peak of flowering date was highly related to average daily mean temperature (R2=0.91) from the start of flowering date to peak of flowering date. However, we did not observe significant differences in the number of inflorescences production. An interesting finding was the observation that the proportion of fruits per inflorescences was significantly higher in the Osso da Baleia than in the Pinheiro da Cruz sites. In addition, the number of fruits aborted was notoriously lower under more mesic conditions. This suggest that mesic climates such as Osso da Baleia may improve A. longifolia fruits development and extended flowering phase which confer a fitness advantage by increasing pollination success. Moreover, in Osso da Baleia the existence of a forest with higher density and plant cover also resulted in higher proportion of fruits by inflorescences and higher number of fruits compared with the values in the open area. In conclusion, the combination between climate and forest structure (density and plant cover) caused pronounced differences in reproductive output of A. longifolia, which justify the larger and more aggressive invasiveness behaviour in the north of Portugal, with more mesic conditions.

Interactions between the dynamics of *Acacia* spp. in Galicia (NW Spain) and forest fire incidence

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Within the genus *Acacia* there are several species which exhibit invasive behaviour. In the region of Galicia (NW Spain) *A. dealbata* Link and *A. melanoxylon* R.Br. are the most abundant of these species. They have expanded from small plots into forest ecosystems and have become the dominant tree species in some areas.
The general objective of this work is to explore methodologies which will allow us to evaluate the importance of fire in explaining the invasive behaviour of *Acacia spp*.
The positive relationship between disturbances and *Acacia spp*. dynamics is considered to be one of the most important factors behind its invasive spread (Brooks *et al.* 2004, Lorenzo *et al*. 2010, Le Maitre *et al.* 2011).
We have combined information on *Acacia spp*. derived from the permanent plots of the National Forest Inventories (NFI) 3 and 4.
The time interval between these two inventories is approximately 10 years. The three available NFI datasets used for defining the “state” of *Acacia spp.* in each plot have been utilized in this study. These are the ‘ocurrence’, ‘regeneration’ and ‘mature tree’ datasets (Figure 1a), compiled from the common and comparable field plots which figure in both forest inventories. We have characterized fire incidence in the region using two different data sources.
The first of these is an “Area Burned Product” derived from the MODIS sensor for the period 2000-2010 (Boschetti *et al.* 2009). The second is based on fire statistics at a spatial resolution of 10 km (1974-2010).
The procedure used to assess the dynamics of *Acacia spp.* over the time period between the NFI-3 and NFI-4 was based on the definition of three types of change: “new” (detected only in the NFI-4), “both” (detected in both) and “lost” (detected only in the NFI-3).
The results reveal a notable increase between NFI-3 and NFI-4 in the number of plots in which *Acacia spp*. was detected and for the three datasets considered (Figure 1b, c and d).
The expansion of *Acacia spp*. to new areas and its consolidation in areas previously invaded can be appreciated.
The number of matched plots for the three datasets provides further evidence of the expansion recorded. The ocurrence of *Acacia spp*. was detected in 417 plots; regeneration was observed in 183 plots and mature trees were recorded in 139 plots. Initial analyses based on various fire incidence variables suggest that little variation exists between the fire incidence registered in the three types of ‘change’.
Acacia spp. is becoming the dominant tree species over large areas and invasion by this species often gives rise to monospecific stands, which in turn may have important implications for future fire regimes.
This situation is particularly relevant in a region where the impact of forest fires is critical in determining the configuration of forest landscapes, particularly given the expected influence of climate change on future fire regimes in these areas (e.g. de la Cueva *et al.* 2012).

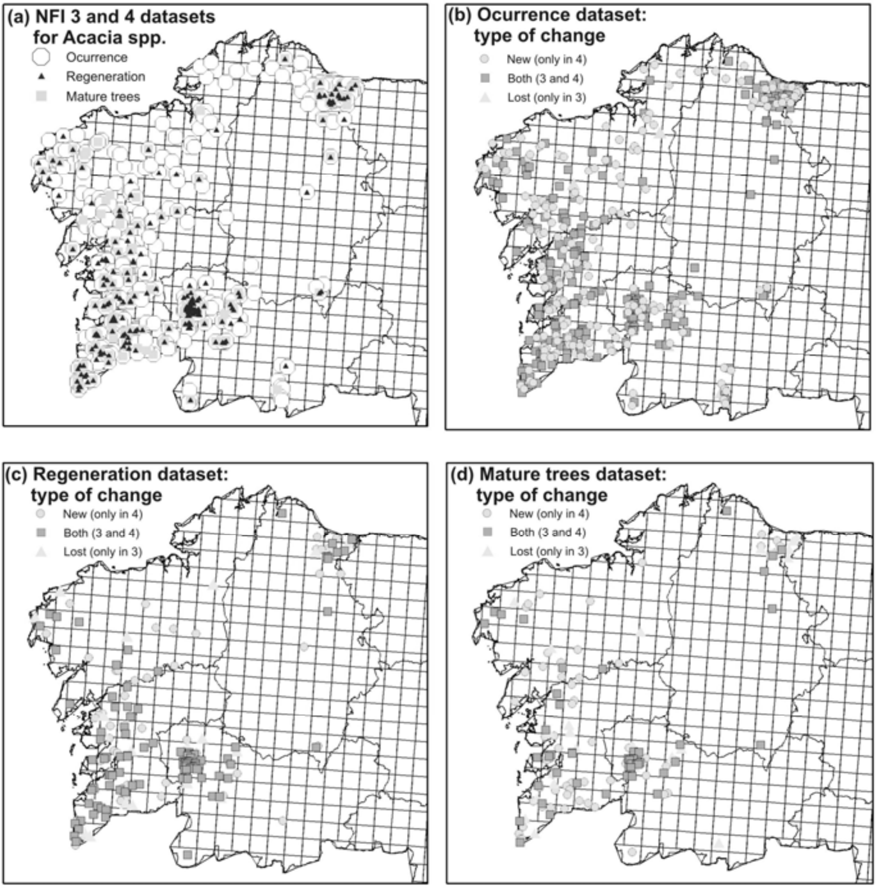

Figure 1. (a) Datasets derived from the common and comparable plots of the NFI-3 (around 1998) and NFI-4 (around 2008) and types of change for the (b) ocurrence, (c) regeneration and (d) mature tree datasets. The 10x10 km grid used in fire statistics is overlaid. The data displayed are limited to Galicia.

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Effects of invasive plants on the structure and diversity of the plant communities after forest fire over time

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The alien invasive species have undergone a considerable increase in the last few years, which produces changes in the ecosystems, such as alteration in communities composition, transmission of pathogens associated with these alien species, or the potential loss of biodiversity (Rejmánek & Richardson 1996; Kolar & Lodge 2001; Wearne & Morgan 2004; MacDougall & Turkington 2005).
Moreover, the environmental disturbances favour the establishment of these alien invasive species, colonising open spaces and modifying the interactions between species. One of these disturbances is wildfire, very frequent in Galicia, and considered to be a special case with respect to invasive species, as their characteristics facilitate the initiation, propagation and intensity of a fire. The object of this study is to know the role of the wildfires in the colonization processes of alien invasive species in burnt shrubland systems in the Galician community.
In 2011, 4 sampling sites in an area that had recently been burnt were selected (Series 0, S0) and also various sampling sites studied also after fire by our group 5 years ago (Series 5 and S5), 15 years ago (series 15, S15) and 30 years ago (Series 30, S30). Two 5x5 m plots were established in each sampling site, which were characterised on the basis of their cover values of the woody species and on the frequency of their woody and herbaceous species. Using the cover data, the value of the Shannon-Weaver index of diversity was calculated and, using the frequency data, the value of relative abundance (%) of the native and invasive species was calculated.
In total 7 exotic plant species were registered, mostly shrubs of the genus *Pinus*, *Eucalyptus* and *Acacia*, the presence of which were registered in the first samplings carried out 15 and 30 years ago. However, their relative abundance considerably increased during these years, especially in the relative abundance of invasive species in sampling sites S30. The native species diversity shows an important decrease from the old samplings to the latest samplings (Figure 1).

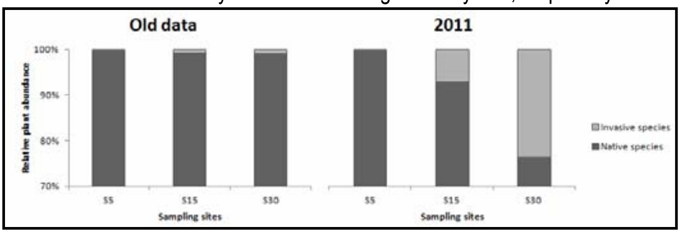

Figure 1. Relative plant abundance (%) of invasive and native species (old and 2011 data), for the sampling sites S5, S15 and S30

These are the first results obtained from a longer term project. However, it has been detected that in the sampling sites in which invasive species were present years ago, their abundance had increased in these years in which they had also suffered more wildfires. (10MDS200007PR).

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Prediction of the *Pinus radiata* reproductive behavior depending on the intensity of a forest fire on the soil

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This work supposes a new point of view in the study of the ecological effects of fire on *Pinus radiata* plantations, because the calorimetry of the soil and the reproductive behavior of an arboreal specie are joined the same study. A soil of Atlantic forest located in Meira (Lugo), repopulated with *P. radiata* and affected by a fire in March, 2010 was selected for this analysis. Samples of burnt and unburnt soils (2 cm depth) were picked up. A Differential Scanning Calorimeter (DSC Q100 TA Instruments) was used to determine de heat of combustion of the organic matter and the ignition temperature of samples of burnt and unburnt soils. From these data the reduction of SOM as a consequence of the fire was determined (Salgado *et al*. 1995). On the other hand, samples of unburnt soil were heated in a laboratory oven at 150ºC and 200ºC during 5 and 10 min. The DSC curves of these samples were also done to clarify the impact of the fire from the comparison with the analogous burnt soil. The thermal parameters determined from the burned soil present similar values than the corresponding to the soil heated in the laboratory to 150ºC during 10 min. This temperature is lower than the ignition temperature of the unburnt soil, 240ºC approximately, indicating that the fire impact in the soil could be situated in the lowest scale. To verify the effects of the fire (heat and smoke) on the germination of two origins of *P. radiata* 12 treatments were carried out: Control, 80ºC-5min, 80ºC-10min, 110ºC-5min, 110ºC-10min, 150ºC-5min, 150ºC-10min, 200ºC-5min, 200ºC-10min, smoke-5min, Smoke-10min and smoke-15min. To determine the fire impact on *P. radiata* regeneration, the seedlings emergency was registered to 0.5, 1 and 3 months after fire.The fire factors presented different effects on *P. radiata* germination dependent with the origin of the species: the heating at the highest temperatures and times of exposition inhibited partially or totally the germination of the studied species, and the smoke, on the other hand, does not affected significantly to the germination. These results agree with found by other authors in several Pinus's species (Reyes and Casal 1995, 2001). The seedling emergency after third sampling was abundant and similar to registered in other burnt pinewoods (Vega *et al*. 2005). From the obtained results, the conclusion of this work is that the fire of Meira in 2010 reached a temperature in soil able to inhibit the germination of *P. radiata* soil seeds. Nevertheless the aerial seed bank resists the heat thanks to the cone protection (Reyes and Casal 2002) and after fire the seeds release allows an abundant and rapid regeneration of the *P. radiata* population.

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Three years of monitoring of *Dreissena polymorpha* population larvae in the eupotamal stretch of the river Ebro (Castejón de Ebro, Navarra)

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Samplings of planktonic larvae were made for a period of 33 months (years 2010-2012) at three sites of the right bank of the river Ebro, close to the Combined Cycled Power Station of Iberdrola SA in an area near the town of Castejón de Ebro. The data reveal a low presence of drifting larvae compared with other points of the Ebro basin, and also a concentration of the maximum of emission of larvae at the end of spring and start of summer.
The breeding period in this central area of the Ebro river occurs from the end of April to the beginning of July, with the maximums detected every year at the middle of June (table 1). The maximum density of larvae was 8200 l/m^3 (14/May/2012), although the yearly average in the period 2010-12 was 3233 and 2583 l/m^3 (May and June respectively). The average monthly content of larvae was compared with the values found in the river Ebro at the sites P1 (2.16 km upriver), P2 (close to the central) and P3 in the interior of the central. In the year 2010 a second emission of larvae was detected in September in the interior of the central, in the pump well. The number of larvae was much lower than in the spring and did not reflect the situation in the natural conditions of the river.
In 2012, an earlier and massive emission of larvae occurred, probably related to the increase in temperature in the first fortnight of May. This demonstrates a near immediate answer with the emission of planktonic larvae when the well's temperature reached 18 ºC. The content of larvae inside the pump well was between 8 and 10 times higher. An immediate and direct relation was found between the presence of larvae in the river and in the interior of the pump well. The detection of planktonic larvae (type D veliger forms) seems to be related with the frequency in the renovation of the water which is pumped from the river to the well in accordance with the production of electricity cycles.
The monitoring of the level of fixation of the pediveliger larvae on submerged "witnesses" in the banks of the Ebro river shows a lesser number than expected, probably because of the hydrologic dynamic of the river in the area where the power station is located. The high turbulence at this bank is not favourable for the settlement of the bentonic larvae. This is caused by the high flow of the river Ebro (usually higher than 100 m^3/s) in the dates of the emission of the planktonic larvae.

Ecological determinants of parasite acquisition by exotic fish species

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Disease-mediated threats posed by exotic species to native counterparts are not limited to introduced parasites alone, since exotic hosts frequently acquire native parasites with possible consequences for infection patterns in native hosts. Several biological and geographical factors are thought to explain both the richness of parasites in native hosts, and the invasion success of free-living exotic species. However, the determinants of native parasite acquisition by exotic hosts remain unknown. Here, we investigated native parasite communities of exotic freshwater fish to determine which traits influence acquisition of native parasites by exotic hosts. Model selection suggested that five factors (total body length, time since introduction, phylogenetic relatedness to the native fish fauna, trophic level and native fish species richness) may be linked to native parasite acquisition by exotic fish, but 95% confidence intervals of coefficient estimates indicated these explained little of the variance in parasite richness. Based on R-squared values, weak positive relationships may exist only between the number of parasites acquired and either host size or time since introduction. Whilst our results suggest that factors influencing parasite richness in native host communities may be less important for exotic species, it seems that analyses of general ecological factors currently fail to adequately incorporate the physiological and immunological complexity of whether a given animal species will become a host for a new parasite.

Environmental variables affecting dispersion patterns and orientation in dry land of two invasive crustaceans: *Procambarus clarkii* and *Eriocheir sinensis*

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The red swamp crayfish, *Procambarus clarkii, and the* Chinese mitten crab, *Eriocheir sinensis*, are two successful invasive species that may impact freshwater or estuarine ecosystems. Although these two species have been thoroughly studied, their overland dispersal capabilities aren't yet well explained. The main goal of this study was therefore to identify environmental variables affecting motion patterns and orientation in dry land.

Motion preferences related to relative humidity, temperature, luminosity, ground slope and vegetation were tested under laboratory conditions. *E. sinensis* or *P. clarkii* were placed, in separate experiments, at the centre of a 2 meter long metal gutter and given a choice between two different values of each variable. Its movements were recorded using a webcam. For each variable we replicated the experiment 30 times, always using a different adult individual and analysed the results using Chi-square.

Regarding the crayfish motion there was no significant preference for high or low humidity, luminosity levels or vegetation. Crayfish had a significant preference regarding temperature, showing a tendency to move towards cooler areas. Likewise, crayfish movement preferences were significantly affected by slope, since they preferred to move downhill. For the crab motion the only significant preference was to move downhill. No other variable affected its movement, possibly because there was a tendency for the crabs to stand still during the experiment.

These results indicate that the crayfish response to these environmental stimuli is more obvious than the crab's response. When out of water, crab's strategy seemed to be to remain in the centre of the metal gutter without moving. The awareness of such preferences and behaviours may help to predict the invasiveness of the freshwater and estuarine ecosystems and to identify the most effective management practices to prevent or contain its spread.

Mediterranean rivers with low hydromorphological impacts constitute a refuge for native fish and amphibians, in front expansion of exotic aquatic species: the case of several basins in northeast Catalonia (Spain)

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Several fish surveys in some Mediterranean rivers in northeast Catalonia have been done from 2006 to 2011. These rivers include a wide range of hydromorphological situations, from pristine status to highly degraded situations with hard modifications of flow regime, river bed, riparian forest and even the presence of artificial barriers. Over 300 stations have been sampled, all along 7 hydrologic basins. Fish surveys were based on passive capture techniques. In each sampling station between 3 and 8 small fyke-nets were left on the river along a day, at least, to estimate relative density (CPUE). This capture technique has been useful to detect other species of aquatic fauna, mainly herpetofauna. All the amphibians potentially present have been captured.

In the surveyed rivers 6 native freshwater fish are present: *Salmo trutta*, *Barbus meridionalis*, *Squalius laietanus*, *Gasterosteus aculeatus* and *Salaria fluviatilis*. Other diadromous species are also present, mainly *Anguilla anguilla*, and several mullets (Mugilidae). On the other hand till 11 species of amphibians can appear on river habitats: *Pelophylax perezi, Rana temporaria, Hyla meridionalis, Bufo bufo, Alytes obstetricans, Pelobates cultripes, Pelodytes punctatus, Triturus marmoratus, Lissotriton helveticus, Salamandra salamandra* and *Callotriton asper*.

A large number of exotic fish and other aquatic fauna have been established in the area, and have appeared on surveys. Common exotic fish in the area are *Pseudorasbora parva, Gambusia holbrookii, Cyprinus carpio, Scardinius erythropthalmus, Carassius auratus, Luciobarbus graellsii, Lepomis gibbosus, Misgurnus anguillicaudatus, Gobio gobio, Barbatula barbatula* and *Esox lucius*. Other exotic aquatic species that occurred frequently are the crustacean *Procambarus clarkii* and the amphibian *Discoglosus pictus*.

Overall results show a high association between native amphibians and several native fish species, mainly *Gasterosteus aculeatus* and *Barbus meridionalis*. The relative abundance of both species correlates positively with amphibians richness, and negatively with number of exotic fish species. Non altered Mediterranean rivers, with a low or none hydromorphological impacts, are the principal refuge for all these native species, where on the other hand the presence of exotic species is generally very low. These rivers have orders between 3 and 4, mainly. On the lowland plains, in natural conditions, this kind of rivers are typically intermittent during summer, when most of the river bed is dry and the only refuge for fish are isolated pools.

In contrast, most of the principal fluvial axis of the area (orders above 4), with high degree of hydromorphological transformations, are intensively invaded with exotic species, native species are absent or scarce, both fish and amphibians.

In this context, only some well preserved Mediterranean rivers arise as refuges for native species in front the progressive establishment and expansion of exotics in impacted fluvial rivers. Unfortunately, these refuges constitute isolated river sections in the context of basins widely modified.

Accomodation phase of a bioinvasion process: evidence based criteria

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The recognition of invasive alien species as a major threat to biological diversity after habitat loss (IUCN 2000) has stimulated increase in scientific effort aimed at different issues of biological invasions, giving a particular attention to the most impacting and extremely successful invaders. At present there is a greater general awareness that practical measures for dealing with alien biota should be undertaken as the knowledge of the levels of impact are recognised by stakeholders, environmental scientists and managers and policy makers. However, many invasive species have population patterns with greater impacts arising from periods of expansion, than at later times (Strayer *et al*. 2006). These patterns may differ dependingly on a number of intrinsic or extrinsic factors, e.g. changes in the species that invades; changes in the biological community that is invaded, cumulative changes in the abiotic environment that is invaded, interactions between the invading species and other variables that control the ecosystem.

Yet there is a lack of empirical support for the generalizations about how much the effects of an invader change through time, the time over which changes occur, and what are the essential thresholds and attributes of different stages of the invasion process. The stages in the invasion process of high impacting species have been defined by a number of authors, but still there is little agreement how these different stages should be distinguished and named. However, most agree on the three major stages typical for many invasion cases following arrival: (i) establishement; (ii) expansion; (iii) accommodation. To become established, an alien species must colonize a site and develop a self-sustaining population. Little or no expansion occurs in this. The expansion stage may reflect one of three distinct forms: 1) a constant linear expansion; 2) a biphasic expansion with an initial slow linear expansion followed by a more rapid linear expansion; 3) or an exponential increase. The accommodation stage (which also has been referred to as adjustment, saturation, naturalization, chronic phase) is reached when the population stabilizes and the geographical extent of the invasion remains approximately constant. At this stage the species is confined within its invasive range.

In this account we examine the history of the zebra mussel *Dreissena polymorpha* invasion in a part of the Shannon river system, Ireland, a series of lakes and river sections navigable by small craft in order to retrospectively evaluate the various stages of the invasion process and distinguish notable attributes of each stage with a special emphasis to accommodation phase.

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Genetic diversity in native and invasive populations of *Taeniatherum caput-medusae* ssp. *asperum* (medusahead): geographic origins, multiple introductions and founder effects

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The native range of *Taeniatherum caput-medusae* includes much of Eurasia, where three distinct subspecies have been recognized, but only *T. caput medusae* ssp. *asperum* (hereafter referred to as medusahead) is believed to occur in the United States (U.S.). Medusahead, a primarily self-pollinating annual grass, was introduced into western U.S. in the late 1800s. The results of an earlier allozyme analysis were consistent with the genetic signature associated with multiple introductions, although this finding can only be confirmed with the analysis of native populations. I compared allozyme diversity in native and invasive populations of medusahead to: identify the geographic origins of the U.S. invasion, test the multiple introduction hypothesis and determine the genetic consequences of these events. Thirty-four native populations of medusahead were analyzed in this study, using enzyme electrophoresis. Five of the seven homozygous multilocus genotypes previously observed in the western U.S. have been detected in native populations. These results provide support for the multiple introduction hypothesis. The geographic origins of these introductions appear to have been drawn from France, Sardinia, Greece and Turkey (Figure 1), although additional analyses are needed. Across native populations, 17 of 23 loci were polymorphic and a total of 48 alleles were detected, while only five polymorphic loci and 28 alleles were found among invasive populations. On average, invasive populations possess reduced within-population genetic diversity, compared with those from the native range. While U.S. populations have experienced founder effects, 38% (17 of 45) these populations appear to be genetic admixtures (consisting of two or more native genotypes). Results of this study have implications for the biological control of medusahead: i) the search for effective and specific biological control agents will have to occur broadly across the species' native range, ii) multiple agents may be required to control invasive populations that are admixtures, and iii) because many invasive populations are genetically depauperate, highly adapted biocontrol agents are likely to be quite effective.

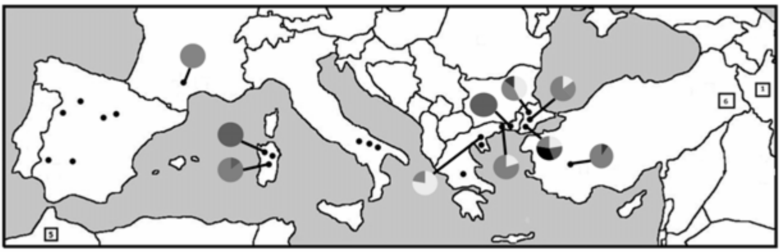

Figure 1. Native range map showing the distribution of invasive range multilocus genotypes found in native populations of medusahead.

Mitochondrial COI diversity in *Mya arenaria* populations from the Romanian Black Sea littoral

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Mya arenaria is an invasive bivalve in the Black Sea, native to the northwestern coasts of the Atlantic Ocean. It has been introduced mainly by intense naval transport and aquaculture. The first record of the softshell clam in the Black Sea dates from 1966, in Odessa Bay. Since then, it had spread rapidly in Romanian and Ukrainian littoral waters. Once it has established populations on the Romanian coast, the softshell clam has produced major changes in the ecosystem, by replacing the native *Corbula mediterranea*. *Mya arenaria* is now the dominant species in the infralittoral ecosystems and a cause for the significant deposits of shells on the beaches.
The genetic variability of the softshell clam populations has been studied with the help of different molecular markers such as alozymes (Lasota *et al*. 2004), microsatellites (Barker *et al*. 2011, Krapal *et al*. 2011) and mitochondrial COI sequence (Strasser & Barber 2009).
We report here preliminary data concerning the COI variability of the *Mya arenaria* populations from the Romanian Black Sea waters. We analyzed a total number of 26 COI sequences from individuals in two populations of *Mya arenaria* from the Romanian Black Sea littoral (11 from Constanta and 15 from Mangalia). We also included in our analysis a number of 212 DNA sequences from populations covering all the current distribution of the species, as described by Strasser & Barber in 2009.
We identified five COI haplotypes in the Black Sea, which were present in both studied populations. Three of these haplotypes (28, 29, 30 in Figure 1) were present only in the Black Sea populations. The minimum spanning tree of *Mya arenaria* COI haplotypes revealed a star-shaped phylogeny (Figure 1) which is characteristic for a species that has expanded in range rather recently from a reduced number of founders (Avise 2000). No geographic structure is evident in the minimum spanning tree topology and the Mangalia (MG) and Constanta (CT) haplotypes are scattered throughout the tree. The results of this study are consistent with previously published data on *Mya arenaria*, which indicate that neutral genetic markers are likely to be uninformative in distinguishing regional populations.

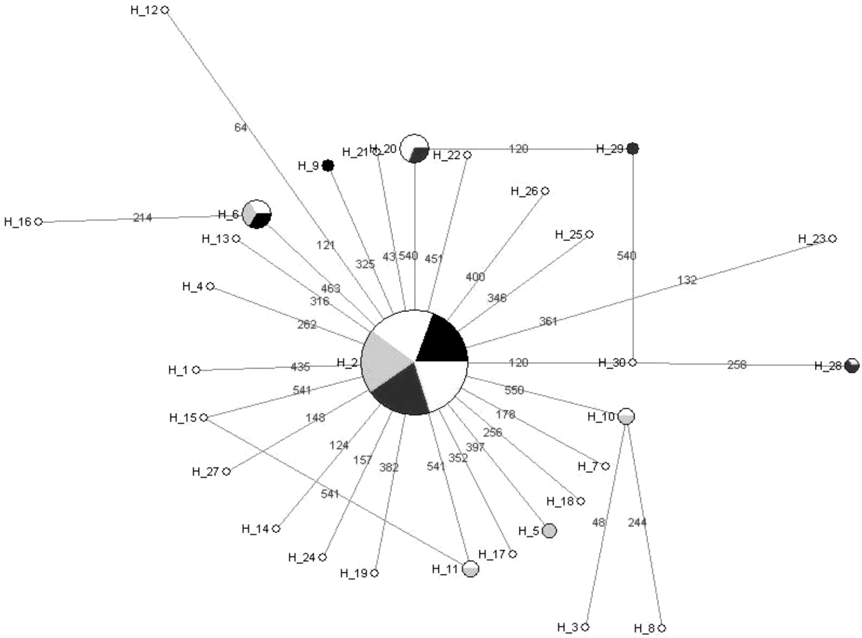

Figure 1. Unrooted minimum-spanning tree depicting the relationship of the mitochondrial COI haplotypes collected from sites in the NW Atlantic (white), North Sea, Europe (black), NE Pacific (gray), Black Sea Constanta (red) and Black Sea Mangalia (yellow). Line distance between circles corresponds to the number of nucleotide differences (one or two). Each circle represents a unique haplotype, and the area of each circle corresponds to the number of individuals with that haplotype (the smallest circles are singletons). The colored slices represent the populations in which the haplotype has been found, but they are not proportional with the number of individuals from each population exhibiting the haplotype.

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Distribution patterns and genetic differentiation of the American mud crab *Rhithropanopeus harrisii* Gould, 1841 from Polish coastal waters

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The American mud crab *Rhithropanopeus harrisii* Gould, 1841 is a non-native crustacean introduced to Europe from the Atlantic coast of North America. More than 50 years ago this species established a stable and abundant population in Poland, precisely in the oligohaline waters of Vistula Lagoon (VL) and Dead Vistula River (DVR). Since the beginning of the 2000s, a sudden appearance of *R. harrisii* has been also observed in the coastal waters of the southern Baltic Sea, in the Puck Bay (PB) and the Gulf of Gdańsk (GG), in places where the crab had not been recorded previously. Although planktonic larvae in the life cycle of this species as well as its high plasticity may suggest high dispersal rate, this crab is known for larval retention mechanism (Cronin 1982). This assumption is also supported by the results of the hitherto studies on the distribution of the American mud crab in the Polish and other European waters which indicate a patchy distribution and genetic heterogeneity. *R. harrisii* was noticed in the Polish coastal waters at depths ranging from 0-20 m, inhabiting areas with muddy bottom or covered by mussel beds, which provide this crab with food and shelter. Carapace width of individuals from Polish coastal waters ranged from 1.96 to 23.30 mm (n = 1014). The highest abundance of *R. harrisii* amounted to 19 ind. x 100 m^{-2} and was recorded at a depth of 6 m in PB.

In order to study gene flow patterns a part of the cytochrome oxidase subunit I gene (mitochondrial DNA) from 20 specimens collected at each sampling site (VL, DVR, PB and GG) was analysed. Sequences of a length of 985 bp were obtained. The number of haplotypes found in American mud crab from Polish waters varied from 3 in VL to 6 in GG. Mitochondrial DNA analyses showed also haplotype diversity at a level from 0.553 ± 0.111 in DV to 0.784 ± 0.053 in GG , whereas the nucleotide diversity was on average at level from 0.004 ± 0.001 in PB and DV to 0.006 ± 0.001 in GG. Based on AMOVA analysis it can be concluded that the population from VL is significantly different ($P < 0.01$), from PB and DV populations. Results obtained from neutrality test showed that all populations from the coastal Polish waters are close to a mutation-random drift equilibrium (neutral model).

It seems that *R. harrisii* is still in the process of expansion in Polish coastal waters, and may have been introduced repeatedly by different invasion mechanisms. Moreover its ecological success might be due to suitable niches in Polish coastal waters.

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The invasion of the seaweed *Sargassum muticum* in the Northern Hemisphere: high success without high genetic diversity

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Alien seaweeds represent one of the largest groups of marine aliens world-wide. For instance, in the North-East Atlantic, 79 seaweed introductions have been recorded (Williams and Smith 2007). Considering the important ecological role of seaweeds in coastal ecosystems, large-scale substitution of dominant native seaweeds by non-indigenous species is likely to strongly impact coastal ecosystems functioning and services. The brown seaweed *Sargassum muticum* is one of the most emblematic non-indigenous seaweed species. Originating from the Northeastern Pacific coasts, it has successfully invaded the Pacific coasts of North America since the 1940s and the North-Eastern Atlantic since the 1970s. Despite its nuisance and large distribution, the introduction pathways and processes in these two areas are not clearly established (Cheang *et al*. 2010). We hypothesized that, similarly to many marine invaders (Roman and Darling 2007), the invasion involved a series of repeated introductions of a large number of founder individuals (i.e. the propagule pressure hypothesis; Simberloff 2009). Such a process leaves a genetic footprint, in particular similar level of genetic diversity in native and introduced populations. Using 14 microsatellite markers specifically developed for this study, we genotyped ca. 1200 individuals sampled in 46 introduced American (from Alaska to Mexico) and European (from Norway to Portugal) populations. Whatever their location, every individual showed the exact same multi-locus genotype. By comparison, native populations were found to be polymorphic: 60 multi-locus genotypes were observed in 8 populations, from Japan and Russia, genetically different from each other; interestingly among them the multi-locus genotype distinctive of the introduced populations was found. This result suggests a severe bottleneck in the invaded areas and a common origin to every introduced population. Assuming that neutral diversity is a proxy for adaptive variation, a link between genetic diversity and invasion success is usually expected: evolution of genotypes better adapted to the introduced range is more likely when selection can operate on large standing (introduced) genetic variation. The lack of polymorphism observed in American and European populations of *S. muticum* does not support such a scenario and suggests that genetic diversity is not a requisite for its long-term establishment. Other factors or processes (e.g. plasticity or epigenetic mechanisms) are likely to explain the species acclimation in the two introduced ranges. Our results advocate for a joint appraisal of genetic diversity, plasticity and epigenetic mechanisms when studying marine invaders.

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Genetic diversity of an invasive alien plant species *Rumex confertus* Willd. in Polish part of its secondary range

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Rumex confertus is an alien species vigorously spreading in Poland. The first station was recorded on the Bug river banks in 1873. Since that time the species started established itself via river valleys, railways and macadam roads. In the last 180 years it become invasive in south-eastern and central part of Poland and it is still scattered in the north and west (Tokarska- Guzik 2005).

To examine genetic diversity of the populations of the studied species we analyzed 6 populations of *Rumex confertus* localized in different parts of Poland. We examined 30 individuals form each of them. Total DNA was extracted from leaf tissues dried with silica gel according to the CTAB protocol. The AFLP procedure was performed as described by Vos *et al*. (1995) using two pairs of selective primers. Total number of fragments recorded was 182, however only 52,7% of them were segregating. The percentage of polymorphic loci per population varied from 27,4% to 15,4%. The mean value of Nei's gene diversity within analyzed populations reached 0.10 and the mean value of among populations gene diversity,in excess of that observed within populations, reaches 0.11. The mean value of F_{ST} coefficient was equal to 0.52.

We reported relatively low level of inter- and intra- populations genetic diversity of analyzed populations. It is know from the literature that the degree of genetic diversity is low for invasive populations especially if the analyzed species is reproduced also asexually, which is a case in this situation.

Some populations composed mainly by seedlings, showed higher percentage of polymorphic loci (27,4%) than the 'older' once (15,4%), which indicate that proportion of sexual and asexual reproduction in long-term dynamic of population can be changed and that the number of progeny produced in sexual *vs*. asexual reproduction modes is probably lowest in older populations.

The obtained F_{ST} valuesuggest that the genetic diversity is retained at both inter- and intra-populations level. However for some particular pairs of populations the coefficient was much higher (0.65). That kind of situation was observed between populations for which geographic distance was the highest, which can be a sign of restricted gene flow between them. Results obtained indicate that the genetic differentiation among populations increase as a function of the distance between them.

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Diversity of *Impatiens glandulifera* populations in Lithuania

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Nowadays many reports are providing evidence about rapid spread and adaptation of invasive species in various corners of the world. First introduced to Europe from Nepal in 1838/1839, *I. glandulifera* quickly became favorite ornamental plant. Nowadays *I. glandulifera* is highly invasive in almost whole Europe including Lithuania where it is distributed through all the country. Concerning Baltic States, *I. glandulifera* data refer mainly morphology, phytocenology and geography. No accounts exist for genetic differentiation of *I. glandulifera* in the Baltic region. The objective of this study was to evaluate genetic variability of differing in geography or habitats Lithuanian populations of *I. glandulifera* by the randomly amplified polymorphic DNA (RAPD) and simple sequence repeat (SSR). A total of 20 populations (15 individuals in each) of *I. glandulifera* were sampled. For SSR analyses 6 locus primers (IGNSSR101/EF025990, IGNSSR104/EF025992, IGNSSR106/EF025993, IGNSSR203/EF025994, IGNSSR210/EF025995, IGNSSR240/EF025997) were used as it is described by Provan *et al*. (2007). Number of samples analyzed was 300. Between 2 and 5 alleles were detected and fragment size ranged from 100 to 165 bp. Genetic parameters of Lithuania populations of Himalayan Balsam were as following: observed heterozygosity (H_o) ranged from 0.053 to 0.677, mean being 0.336. Respectively expected heterozygosity (H_e) ranged from 0.122 to 0.401, mean being 0.212. For RAPD analyses 8 primers (OPA-20, OPD-20, 222, 250, 269, 340, 474, 516) were used (Zybartaite *et al*. 2011). Selected RAPD primers generated between 18 and 30 bands each, in total 188 bands were recorded and all of them were polymorphic. Among populations of *I. glandulifera* genetic parameters ranged in the following intervals: percentage of polymorphic DNA bands ranged between 40 and 56 %, Nei's gene diversity (h) interval was 0.115–0.165 and Shannon's information index ranged between 0.179–0.255. Pairwise genetic distances between populations were 0.088–0.259. The UPGMA dendrogram revealed clear differentiation between the populations, PhiPT value was 0.511 ($p \leq 0.01$). Our RAPD analyses indicate multiple introduction of this species in Lithuania. Presumably several different ways of invasion of *I. glandulifera* took place: natural run and predisposing it intentional and unintentional dispersal by human. According to our habitat analyses the most successful *I. glandulifera* invasion occurs from the yards along roads with excavated in parallel dikes.

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Studies of habitats and genetic diversity of *Impatiens parviflora* in Lithuania

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Across many countries of Europe study is in progress concerning pathways of invasion, the role of habitats, the role of species traits in determining invasiveness, ecological and economic impact of invasions, and risk assessment. One of the most invasive species in the woods of Central and Northern Europe is small balsam (*Impatiens parviflora*), an Asiatic species. Its introductions appear to be increasing in forest ecosystems and are considered harmful. This species is affecting ground-layer vegetation displacing native community components having similar biology. Small balsam is valuable model for invasiveness investigation. Present study aimed at evalution of genetic diversity of *I. parviflora* populations growing in the geographically contrasting areas of Lithuania. Interrelations between habitat features and genetic variability of *I. parviflora*, were tested employing two following methods: RAPD (Randomly Amplified Polymorphic DNA) and SSR (Simple Sequence Repeats).
Natural and anthropogenic habitat features of selected sites of *I. parviflora* were classified according to the water source and its proximity: 1) overmoistured, parallel to the dike / groove / stream, 2) in a 50–100 m distance from the river bank, 3) no water basin in the vicinity. Light intensity was characterized estimating life form of neighboring plants: 1) open place with shrubs / separate trees, 2) park / forest edges of the woods, 3) roads, paths inside wood). Sites were subdivided taking into account traffic intensity and road type also vicinity: 1) along blacktop road with intensive traffic, 2) along blacktop road of the city / town with low intensity traffic, 3) along the road without blacktop or along footpath in the forest. Proximity to any type of the buildings was recorded: backyards of the estates / houses / farms with escapes from the managed plot, absence of any type of the building. Population size (estimated according to the length of transect through the population) was as follows: small size (< 100 m), intermediate size (100–500 m), big size (500–1000 m), very big size (> 1000 m). Data show that in Lithuania, *I. parviflora* occurs abundantly in disturbed by human localities – urban sites, roadsides, parks or forest edge.
It has gradually been recognized that ecological attributes alone are insufficient to explain why some plant species become invasive. This has led for more genetic studies of introduced species. Various different mechanisms might be implicated in generating the genetic variation underlying rapid adaptive evolution and the colonization of new habitats. Genetic diversity of Lithuania *I. parviflora* populations was evaluated also according to microsatellite markers. Five out of seven SSR primers (INGSSR101 EF025990, IGNSSR103 EF025993, IGNSSR203 EF025994, IGNSSR210 EF025995, IGNSSR240 EF025997) designed for *I. glandulifera* generated DNA bands and were selected for the analyses. Eight out of thirty RAPD primers 222, 250, 269, 340, 474, 516, OPA-20, OPD-20 generated recordable DNA bands and were selected for the analyses). There was no tight relation between genetic and geographic distances of populations of *I. parviflora.*

Characterisation of phenotypic plasticity in seedling stage of native and invasive populations in *Ambrosia artemisiifolia* L.

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Increased phenotypic plasticity has often been invoked as an hypothesis to explain the capacity of alien invasive plant species to colonize new environments, because it may enhance the ability of plants to cope with new biotic and abiotic conditions. Following this hypothesis, alien invasive populations should be represented by more plastic genotypes than populations in the native range. In annual species, the seedling stage is of crucial importance for population dynamics but surprisingly very few studies have investigated differences in phenotypic plasticity on seedling traits. Based on populations from the native range (North America) and the invasive range (France) of *Ambrosia artemisiifolia*, we evaluated whether invasive populations exhibit higher levels of phenotypic plasticity for seedling traits (seed germination and hypocotyl's growth) than native populations. We suspect that phenotypic plasticity has genetically evolved during the invasion process in Europe, since the original admixture. We also compared the level of phenotypic plasticity between invasive and non-invasive historical populations (i.e. historical populations that have been localised from herbarium specimens and that did not expand following introduction) in Europe in order to test whether evolution of phenotypic plasticity occurred with invasiveness. We measured seed germination patterns and hypocotyl's growth in 3 native, 3 historical and 3 invasive populations of *A. artemisiifolia* L. for population differentiation in plasticity to 7 levels of germination temperature. We used the loess smoothing procedure to analyse the complex norms of reaction and to quantify total plasticity to temperature for each population *(*Simons & Wagner 2007*)*. Then, we compared seed germination and hypocotyl's growth traits expressed at population and half-sib family levels, in two temperature environments. The continuous norms of reaction for each of the 9 populations of *A. artemisiifolia* exhibited similar patterns of germination through the temperature gradient and total plasticity level was not significantly different for the 9 populations tested. The 95% confidence intervals of loess predictors overlapped for cold and warm temperatures. Furthermore, there was no evidence for a differentiation in germination for population statuses (native vs. historical vs. invasive). However, above 8°C, germination was significantly different among historical populations although this was not the case among populations of other statuses. Reaction norm differences among populations and half-sib families were observed for germination and hypocotyl's growth traits. However we did not find any evidence of differentiation due to population status and no significant interaction with the environment. These results suggest that there was no evolution of plasticity after introduction and during invasion process. Besides, we did not find any differentiation in germination and hypocotyl's growth trait responses for the geographical origin or the age of invasive populations. The populations tested did not exhibit any rapid evolutionary change in seedling traits although the historical invasive populations exhibited higher differentiation in seed germination compared to native and recent invasive populations.

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Ulmus laevis and *Ulmus pumila* two stories to compare

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Besides the two elm species considered native, i.e. *Ulmus minor* Mill. (Field elm) and *U. glabra* Huds.(Wych elm), two other elm species are commonly found in Italy: *U. laevis* Pall. (European white elm) and *U. pumila* L. (Siberian elm), which botanists agree in considering as "exotic cultivated". *U. laevis* is widely used in parks and gardens because of its capacity to avoid Dutch elm disease (DED) infection (Sacchetti *et al.* 1990) while *U. pumila* was planted over the landscape during the 1930s to replace the Field elms destroyed by the first DED epidemic. In relatively remote areas of north-western Italy, along rivers and streams, several small and scattered *U. laevis* populations were recently identified, for which a native status might be suspected. We sampled numerous individual at each of those populations and compared their nuclear and plastidial SSR markers profiles with those of French natural populations.
In addition, we investigated the swarm of elm trees with intermediate characters between Field elm and Siberian elm, whose occurrence has been long observed in Italy. The potential for hybridization between these two species is high (Cogolludo-Agustin *et al.* 2000) and repeated hybridization could result in the genetic swamping of the native species and facilitate the evolution of invasiveness in the introduced species. We used genetic markers to examine the extent of hybridization between these two species and to determine the pattern of introgression. We quantified and compared the level of genetic diversity between the hybrids and the two parental species.
The populations of European white elm in northwestern Italy appeared not to be related to the French native populations. The high heterozygosity suggests that these fragmented Italian populations may be relics of a wider population ranging the whole Po valley, before the dramatic man-mediated changes that have upset the natural ecosystems of this area, such as drainage and intensive agriculture practices.Hybrids between *U. pumila* and *U. minor* were common. We did not observe as strong a pattern of biased introgression towards *U. pumila* as had been recorded in previous studies.
Second-generation hybrids between *U. pumila* and *U. minor* are likely to occur in Italy although they were not detected between *U. pumila* and *U. rubra* in the Midwestern United States (Zalapa *et al.* 2010).
The likely presence of F_2 individuals in the hybrid population in Italy suggests the expression of new genotypes which may facilitate rapid evolution.The self-compatibility of *U. minor* and its propensity to reproduce clonally may facilitate the formation of F_2 individuals in *U. minor-U. pumila* hybrid populations which in turn set the stage for rapid evolution and for the potential evolution of invasiveness of *U. pumila* in Italy.

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Rapid evolution in biological control systems

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Alien invasive species have become model systems for the study of rapid evolution, i.e. genetically based changes that occur over decades or a few hundred years. Deliberate introductions of exotic organisms for the biological control of invasive species share many of the same characteristics as invading species, yet post-introduction evolution of biological control agents is largely unexplored. This is surprising, given the number of introductions and subsequent establishments of classical biological control agents in distinct environments over the past decades, and the fact that both the geographic source(s) of initial releases and the founding population sizes are often well documented. A more thorough understanding of the prevalence and factors contributing to rapid evolutionary changes in exotic biological control agents not only helps tackling fundamental questions in evolutionary ecology, but also contributes to an improved risk assessment of deliberate releases of exotic organisms.
One of the biological control systems that have been assessed in terms of post-introduction evolution both at the invader and the biological control agent level is tansy ragwort, *Jacobaea vulgaris*, and the biological control agent *Longitarsus jacobaeae* (Col., Chrysomelidae). Tansy ragwort, which is native to Eurasia, was accidentally introduced in North America some 100–130 years ago, and *L. jacobaeae* some 40 years ago, first from Italy and more recently from Switzerland. There is evidence that tansy ragwort populations in the invaded range have evolved shifts in plant secondary metabolism, probably due to altered herbivore pressure in the introduced range. Because the release history of the biological control agent *L. jacobaeae* is well known, there is even stronger evidence for rapid evolution in the biological control agent itself. The evolutionary changes in life-history traits of *L. jacobaeae* observed so far are likely to be due to adaptation to new abiotic environmental conditions encountered in the introduced range. These findings will be compared with other studies assessing rapid evolution in biological control systems.

Do indigenous phytophagous insects and fungi prefer exotic or native trees?

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Exotic trees and shrubs planted in arboreta provide excellent tools to study various ecological hypotheses linked to biological invasions. In Russian and Swiss arboreta, we tested whether alien woody plants are less attacked by native herbivorous insects than their congeneric species, a prerequisite for the enemy-release hypothesis, which suggests that invasive species do better in their area of introduction because they are released from the natural enemies that control them in the area of origin. We also tested the hypothesis that endophagous insects show stronger preference for native woody plants than ectophagous insects because these latter tend to be more generalists than endophagous species.
Field studies were made in 2008-2011 in two arboreta in Switzerland, five in Siberia and one in the Russian Far East, to compare the level of attack by native insects on native and alien congeneric woody plants. In each arboretum, pairs of congeneric woody plants were selected. Pairs of plants consisted of a tree or shrub belonging to a native species and a tree or shrub belonging to a congeneric exotic species. In all regions investigated, endophagous insects (leaf miners and gall makers) were more abundant on native plants than on alien congeneric plants, supporting the enemy release hypothesis. Native plants also hosted more species of leaf miners and gall makers than exotic plants. Alien plants originating from geographically distant regions were even less colonized by native endophagous insects than alien plants originating from neighbouring regions. In contrast, damage by external defoliators was not significantly different between native and alien congeneric plants. A similar study carried out in various arboreta in Siberia showed that foliar fungal pathogens were significantly more abundant on native woody plants than on exotic woody plants.
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Historical demography and origins of invasive biotypes in the whitefly *Bemisia tabaci* complex

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Distinguishing new invasions from established older invasions is important, not only for management and trade, but also for understanding and predicting population dynamics and adaptation to a changing environmental. Here, we review cryptic invasions of arthropod herbivores in 4 agricultural systems in Europe. Despite the similarity in foraging mode and taxonomy, these studies show that generalizations about the patterns and impacts of cryptic invasions will be difficult. However, knowledge and understanding in each system has been possible through the use of monitoring, genetic diagnostics, collections, and specimen-level databases. Further, these studies illustrate the importance of specimen-level data (rather than at the level of species) to test hypotheses about the timing and impact of cryptic invasions.

Bemisia tabaci whiteflies are a complex of morphologically cryptic lineages, termed “biotypes”, that differ in host use, insecticide resistance, and competitive ability (Hadjistylli et al 2010, Stansly & Naranjo eds, Springer). Biotypes are partially reproductively isolated and have replaced each other world-wide. Two invasive biotypes (B and Q) exhibit high levels of genetic diversity, consistent with continuing human-mediated migration (Hadjistylli et al 2012a). Demographic histories of both B- and Q-biotypes suggest that ancestral populations had much larger effective sizes than those of emerging biotypes. The origins of both B- and Q-biotypes in Europe coincides with periods of human migration (Hadjistylli et al 2012b).

The spider mite *Tetranychus evansi* is an emerging pest of solanaceous crops worldwide (Boubou et al 2011, *Biological Invasions*). By distinguishing among multiple pathways and timing of introductions, evidence exists for the ‘‘bridgehead effect’’, in which one invasion serves as source for subsequent invasions. Populations in Europe and Africa resulted from at least three independent introductions from South America (Boubou et al 2012, *PLoS One*).

The olive fly, *Bactrocera oleae*, is a pest of olives (*Olea)* in Europe and elsewhere (Nardi et al 2005, *Molecular Ecology*). Historical reconstruction shows that early subdivision of the olive fly reflects the Quaternary differentiation between olive subspecies in the Mediterranean and two lineages in Africa and Asia. However, the geographic structure and timing of differentiation in the Mediterranean indicates a post-glacial recolonization of wild olives in the area and to cultivated olives in historical times and more recently (Nardi et al. 2010, *Molecular Phylogenetics and Evolution*).

Aphids in the genus *Hyalopterus* (Hemiptera) feed on plants in the genus *Prunus* (Rosaceae). Three deeply divergent lineages are structured in large part by specific associations with plum, almond, and peach trees (Lozier et al 2007, *Evolution*), with no evidence that geographic or temporal barriers could explain the overall diversity in the genus, despite worldwide movement of host plants and the potential for ongoing hybridization (Lozier et al 2009, *Biological Invasions*).

Genetic characterization of Zebra mussel invasion in Ebro river

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Zebra mussel (*Dreissena polymorpha*, Pallas 1771), native from the Ponto-Caspian region is a successful invader of rivers and lakes worldwide, which cause very important ecologic and economic impacts. From its initial invasion in 2001, detected in the middle section of Ebro River (Spain), the zebra mussel has expanded along all Ebro river. In the year 2011, it was also detected in other Iberian North-East rivers, such as Llobregat river (Barcelona).
The main objective of this study is to assess the genetic diversity and the routes of dispersion. Thus, we analyzed 498 zebra mussel individuals of ten representative locations including the Ebro and the Llobregat rivers using ten polymorphic microsatellite loci. Five of these microsatellites have been isolated by 454-Roche Next Generation Sequencing (NGS), and subsequently validated for a complete characterization. Finally, genotyping was performed by two Multiplex Polymerase Chain Reactions (PCR).
No deviation in Hardy-Weinberg Equilibrium was detected. Population analysis showed high levels of genetic diversity, with similar values in all locations (He = 0.614 - 0.673). Bayesian inference analysis (STRUCTURE, BAPS) failed to detect heterogeneity among populations, suggesting that all locations are the same homogenous genetic population. These results are compatible with the hypothesis of a single, recent introduction episode of zebra mussel in Ebro and Llobregat rivers.
Pairwise populations genetic difference (F_{ST}) was only significant between Llobregat and Ebro basins comparison. This result was confirmed by molecular analysis of variance (AMOVA), where the genetic difference among different rivers was significant (F_{CT} = 0.028; *P* = 0.018) while the genetic differentiation among locations within Ebro river was not significant (F_{SC} = 0.006; *P* = 0.105). Phylogenetic analysis corroborated the absence of population structure but it suggested an incipient differentiation of Llobregat.
Heterozigosity excess analysis (BOTTLENECK) detected no bottleneck episodes, suggesting a current exchange of large number of individual among locations.
In summary, our results indicated the origin of Ebro and Llobregat zebra mussel seems to belong to same invasion event. Nevertheless, we detect an incipient differentiation of Llobregat river population.

Different morphological forms of the Asian clam (*Corbicula* spp.) in European waters, but only one COI mitochondrial haplotype

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Corbicula fluminea is a bivalve native from South-East Asia and noticed for the first time in Europe in 1980, in France and Portugal. The rapid expansion of this species throughout Europe can be explained by several factors, either associated with anthropogenic activities (e.g. ballast water transport, aquarium releases, naval traffic and opening of a new channels connecting different water bodies) or with the species biological traits (e.g. early sexual maturation, high fecundity, fast growth).
Species from the *Corbicula* genus exhibit different reproductive strategies, with sexual dioecious as well as hermaphrodites species. The hermaphrodite lineages of *Corbicula* spp. are reproducing through a rare form of asexual reproduction, known as androgenesis, in which offspring are clones of their father. The main objective of our study was to investigate the genetic and morphologic variabily of *Corbicula* spp. populations in Europe. In this study, we collected samples in Minho estuary (N-Portugal) (2 sites) in Mero river (NW-Spain) (2 sites), Hollandsch Diep and Waal River (The Netherlands, 3 sites), Loire and Dreé rivers (France, 2 sites), Meusse River (Belgium, 1 site), Iskar River, Negovan Lake and Danube River (Bulgaria, 4 sites) and Danube and Timis rivers (Romania, 4 sites). Three morphometric variables were measured in 558 specimens from 18 populations (shell length- SL, shell width- SW, shell height- SH) and the SW/SL, SH/SL and SW/SH ratios were computed. A non-parametric multivariate analysis of variance revealed clear morphological differences in 115 out of 153 populations pair comparisons ($p < 0.0001$). Differences among populations might be due to adaptations to local ecological setups, to the population's origin and thus related with distinct selection processes. We sequenced a DNA fragment of 620bp from the mitochondrial COI gene in 63 specimens of *Corbicula* spp. collected in the 14 sampling sites mentioned above (Portugal, Spain, France, Belgium, Netherlands, Bulgaria, Romania). We combined our dataset with 21 DNA sequences available in Genbank from previous studies (Pigneur 2011, Bodis *et al*. 2011, Schmidlin 2012), in order to have a broader image of the genetic diversity of *Corbicula* in Europe, at this locus. All the analyzed specimens exhibited the same mitochondrial haplotype FW5, confirming the low genetic diversity of *Corbicula* in Europe, for this genetic marker. This fact might be related with their clonal reproductive mode, however other genes should be analyzed to improve our knowledge on the invasion history of *Corbicula* across European waters and then be able to propose management measures to prevent the spread of *Corbicula* or other bivalve invasive species across Europe.

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Comparative genetic diversity patterns of mosquitofish populations among invaded watersheds

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Biological invasions are one of the major threats to biodiversity and also an unappreciated opportunity to study evolutionary processes at small spatial and temporal scales. The eastern mosquitofish (*Gambusia holbrooki)* has been worldwide introduced to control mosquitoes acting as disease vectors. Mosquitofish genetic diversity patterns have been found to be correlated with some environmental variables such as river flow and connectivity. Within watersheds, isolation by distance and spatial autocorrelation of allele frequencies have been observed in native American populations. Previous data detected a common genetic origin of *G. holbrooki* populations in the Iberian Peninsula. In this work, using microsatellite loci, we compared patterns of population diversity of mosquitofish among 4 northeastern Spanish watersheds (Ebro, Ter, Fluvià and Muga rivers), raised up after their invasion in early 20th century.

Overall higher amount of genetic diversity in the study Ebro river populations was interpreted as an earlier introduction into this basin than in northward watersheds (Ter, Fluvià and Muga rivers). The total amount of genetic diversity within basins was higher in rivers with high water flow. Diversity was also independent of the length of the studied river section, but related with river width as wider rivers may hold larger populations. Assignment tests did not detect current exchange of individuals between the Ebro River populations and northward watersheds. However, some degree of connectivity has been identified among the lowland populations of the three northern basins. These two observations were in agreement with the moderate amount of divergence detected among all populations (F_{ST}=0.12). Within all study watersheds, slightly correlation between levels of genetic differentiation and distance between populations suggests a pattern of isolation by distance. The highest value of differentiation within watersheds was detected in Fluvià river (F_{ST}=0.081) and the lowest in Ter river (F_{ST}=0.011) where the distance between populations were 50 km and 19 km, respectively. The presence of a dam in the study section in the Ebro River was not related with increased genetic differentiation. These results support the formidable dispersal ability of *G. holbrooki* and its capacity to overcome human-mediated barriers and habitat fragmentation.

Reproductive parameters of topmouth gudgeon from a heated Lake (Licheńskie, Poland)

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Topmouth gudgeon (*Pseudorasbora parva* Temminck & Schlegel, 1842) is one of the most invasive organisms in Europe. Our previous studies revealed shifts in reproductive traits of several invasive populations of this species and demonstrated its high phenotypic plasticity (Záhorská *et al*. 2012). Thus, the main aims of the present study were to: 1) examine if the reproductive parameters of a population living in permanently heated water differ from those of populations from habitats with normal temperature regime; 2) test the hypothesis of alternative ontogenies and invasive potential (Kováč 2011), which predicts that reproductive parameters of this invasive population soon after its introduction (2003) will differ significantly from those after the population has established (2011). The specimens were collected throughout each reproduction season between 2003 and 2011 from the Lake Licheńskie, which forms a part of a power plant cooling system. Water temperature in this lake does not decline under 16° C. A total of 1,415 specimens, with the sex ratio 1.23:1 (female:male), was examined. The standard length (SL) in females ranged from 18.90 to 77.09 mm. The gonadosomatic index varied within the interval 0.06 – 53.10, suggesting that the spawning season of topmouth gudgeon from the Lake Licheńskie starts in April and ends in June. Females were found to mature at a very small size (18.90 mm SL), and 100% of individuals at 33.01 – 36.00 mm SL were mature. Preliminary results suggest that, in females, 1 to 4 size-groups of oocytes can be clearly distinguished. During the spawning period the size of oocytes ranged from 0.08 to 1.52 mm, with the tendency to increase from year to year. Differences between years were also found in the absolute number of oocytes that varied from 2 622 to 18 254 (preliminary results), with the tendency to decrease from year to year. Such absolute numbers of oocytes are significantly higher than in other invasive populations of topmouth gudgeon (e.g. from Slovakia). The preliminary results were found to be as expected based on the predictions, and therefore support the hypothesis tested.

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Alien snakes in Balearics: Combining molecular tools and GIS to determine the invasion and expansion patterns

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The species introductions shape the vertebrate communities in greater extent in the Mediterranean Basin that in other biodiversity hotspots. Harbouring simpler communities constituted by species evolved under relaxedness competition, Mediterranean islands are especially vulnerable to biological invasions. Determining the origin of such aliens is the first step to develop successful strategies of prevention and minimisation. Reptiles in the Balearic Islands represent a paradigmatic case, with more alien than native species. In this work, we identify the allochthonous status and the putative origin of the snakes *Hemorrhois hippocrepis*, *Malpolon monspessulanus*, *Macroprotodon mauritanicus, Natrix maura* and *Rhinechis scalaris* by using molecular markers. We also estimate the habitat suitability and anthropic favoring factors for each species using GIS models in an attempt to infer their patterns of invasion and expansion. This information is expected to provide insights on pathways by which these snakes have arrived to the islands and aid preventing new introductions and to implement control measures by policy makers. We assessed the origin of all the snakes sampled using several molecular markers (Cytb, ND4, COI) by putting sequences generated together with those published for the species both in its autochthonous range and in other introduced populations. Results are discussed in the context of the phylogeography of each species and its invasive character. For most of the species molecular data allowed identifying the potential source of the allochthonous population. Finally, we determine the importance of each factor (tree nurseries, human density, climate, land use) through the time for every species. This multi-approach, joining molecular data with ecological modeling together, reveals a promising tool for understanding of the complex invasion process and, hence, supporting conservation planning.

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Colonization of Brazil by the invasive cattle egret (*Bubulcus ibis*) revealed by mitochondrial DNA

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Several bird species have been introduced to nonnative areas by human intervention, but the cattle egret (*Bubulcus ibis*, Linnaeus 1758) is historically known to have established and expanded into the New World without human participation (Telfair 1983).This egret has been considered to be an invasive species according to the International Union for Conservation of Nature's Invasive Species Specialist Group (ISSG). The American cattle egret population started when egrets crossed the Atlantic Ocean and established in the Guianas region of the South America. The study of the colonization of Brazil, a continental country, by this African egret offers an excellent opportunity to understand the occupation of extensive areas by this exotic bird. This study aims: a) to determine the genetic diversity in Brazil and Africa, b) to verify if the entrance point and the time of the cattle egret arrival is in accordance to the historical reports, and c) to investigate the direction and intensity of the gene flow between these two sampled areas. Mitochondrial control region (CR) sequences were obtained from Brazilian and African populations (Kenya, Ghana and Nigeria). Genetic diversity (H, *h*, ſs) and population structure (AMOVA, F*st*) were evaluated in five Brazilian and four African populations. The amount and direction of gene flow between Brazil and Africa were inferred using a Bayesian approach implemented by the MIGRATE-N and IMa programs, and the time since the splitting of the two populations was estimated. Among the 34 detected haplotypes, 25 were from Africa, 13 were from Brazil and four were shared haplotypes. The diversity levels were similar between Brazil and Africa. The pairwise F*st* values between the populations from these two areas were all significant. The northern Brazilian population showed the lowest differentiation with respect to the African population, followed by the southern, southeastern and northeastern populations. The dispersal pattern matches the environmental characteristics and the high bovine/pasture areas of the southern region of Brazil in comparison to the other sampled regions. Results agree with the historical report of cattle egret entrance via the northern region of Brazil where they were first recorded in 1964, feeding along with buffalos on Marajo island, Para state (Sick 1965). The arrival of cattle egret in the American continent was estimated to have occurred 287.5 years ago. A hundred and thirty five years have passed since the first cattle egret was reported in the Guianas region. Considering that this species can reproduce twice a year and reach sexual maturity at one year of age, we can assume a maximum of 270 generations, since the entrance of cattle egrets into South America. Results suggest no migration from Brazil to Africa, and current migration from Africa to Brazil can indeed be ruled out. Data are showing that the colonization of the Brazil can be considered a result of a small number of migration event(s) that occurred in the past.

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Genetic variation of raccoon dogs (*Nyctereutes procyonoides*) in Lithuania

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The raccoon dog (*Nyctereutes procyonoides*) is alien species in Europe that spread rapidly into many European countries and has significant ecological impact on native ecosystems. In Lithuania the raccoon dog has been first observed in 1948 in the eastern part of the country. The size of raccoon dog population in Lithuania varied in different periods, and today this species is widely spread. Since 1970 raccoon dog is declare as invasive species in Lithuania and hunting is permitted throughout the year. However the genetic structure of population is not clear.
The aim of our study was to investigate genetic variability and genetic structure of population of raccoon dog in Lithuania.
Short tandem repeats (STR) and mitochondrial DNA control region (D loop) were used as molecular markers. Tissue samples of 269 raccoon dogs were collected by hunters during period 2007-2011 from different locations in Lithuania. Genomic DNA was extracted from frozen liver and muscles.
We used sequence data of the mtDNA control region (565 bp) to evaluate the distribution of genetic variation among *Nyctereutes procyonoides* collected from 19 Lithuanian districts. In total, eight haplotypes were found in raccoon dogs in Lithuiania. Phylogenetic relationships between the haplotypes demonstrated presence of two haplogroups. However these haplogroups were not related with spatial geographic structure of the population. Similar phylogenetic patterns were identified in raccoon dogs from Western Europe (Pitra *et al*. 2010) and in European part of Russia (Korablev *et al*. 2011).
The variability of 15 canine microsatellite loci was examined in raccoon dog randomly selected from 10 Lithuanian districts. Seven loci (FH2010, FH2096, VWF.XF, FH2054, FH2004, PEZ-17, and REN112I02) that generated PCR products were selected for analysis. Six of them displayed a polimorphic alleles. The numbers of alleles per locus, allele frequencies, observed and expected heterozygosity at the locus were estimated, and the distances between analyzed populations were determined. The total number of alleles per locus varied from 4 to 9. Analysis of molecular variance (AMOVA) showed that genetic diversity of the populations yielded highly significant differences within populations (91% of the total genetic diversity) and among populations (9 % of the total genetic diversity).
The present data revealed a high level of molecular genetic variation in microsatellite loci and mtDNR control region and showed that raccoon dog population in Lithuania is heterogenic and consisted of separate maternal lineages.

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The genetic variation of muskrat (*Ondatra zibethicus*) in Lithuania

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The muskrat species *Ondatra zibethicus* homeland is North America but they were released in several rivers in Lithuania since 1954. The muskrats spread almost all over the country after acclimatization and today are subsumed as the invasive species in Lithuania. In different years the number of muskrats were very varied from 40 000 to 1000 individuals. The declining population number of muskrat is one of the factors related to accelerated inbreeding and loss of genetic diversity. The aim of this study was the examination of genetic variability of invasion species muskrat and bioinvasion situation in Lithuania. The population samples of muskrat were collected from eight regions of Lithuania. The genetic variation of the muskrat populations were analysed by microsatellites. Acording to Laurence *et al*. (2009) 12 microsatellites primers (Oz06, Oz08, Oz16, Oz17, Oz22, Oz27, Oz30, Oz32, Oz34, Oz41, Oz43, Oz44) were used in this study. But 9 of these 12 microsatellite loci were used in subsequent analyses in case 3 of them (Oz34, Oz27, Oz32) were not informative. The number of polymorphic loci is 76 % and size ranged from 134 to 291 base pairs. The genetic diversity among muskrat individuals ranging from 0.14 to 0.68. Standard diversity indices, deviation from Hardy-Weinberg, the inbreeding level and tests for genetic bottlenecks were applied in this study. These markers will be useful for further studies and which will give more details about the genetic structure of population in muskrat. The impact of muskrats on native species and communities (C0-C2) were analysed.

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